THE EAST BAY SHORELINE

Selected Environmental Issues

BERKELEY: DIVISION OF SPECIAL PROGRAMS
301 CAMPBELL HALL

November 2, 1982

TO: Governmental Studies Library

FROM: W.B.N. Berry, Chair, Environmental Sciences Program

Enclosed find a copy of The Eastbay Shoreline: Selected Environmental Issues edited by Doris Sloan, Instructor in the Environmental Sciences core courses and the senior seminar series. This volume comprises the reports of the 1982 graduating class in Environmental Sciences.

As you may note from the attached copies of correspondence received concerning this report, a number of state agencies (State Lands Commission, San Francisco Bay Conservation and Development Commission, The California State Coastal Conservancy) have found the report valuable and useful. As may be seen as well from these copies, the Save San Francisco Bay Association made a contribution toward printing the report.

The Advisory Committee to the Environmental Sciences Program are pleased to see that this practical application by undergraduates of their educational experience at Berkeley has been so widely and warmly received. That undergraduates have written such a well received report indicates that Berkeley undergraduate education cannot only be a rewarding experience but also can generate valued research results.

The California
State Coastal
CONSERVANCY

October 25, 1982

Ms. Doris Sloan
Environmental Sciences
Division of Special Program
301 Campbell
University of California
Berkeley, California 94720

Dear Professor Sloan:

On behalf of the Conservancy and the East Bay Shoreline Advisory Committee I would like to express our appreciation for the excellent work produced by you and your class on the East Bay Shoreline Plan.

The active involvement of your environmental science seminar in the community planning workshops was very useful to us. I hope it also provided a valuable education into how academic or theoretical concepts can be translated into decision making at a grass roots and at a state government level. The list of speakers who made presentations to your class is quite impressive and appears to include most of the experts on the East Bay Shoreline environment. The class papers synthesize in one document for the first time a wide array of plans and scientific reports and, through individual interviews and new research, point out a number of issues and problems that should be explored further by agencies responsible for the Bay. I find the class publication very useful and suggest it as a reference frequently.

The multi disciplinary approach of the senior seminar in envronmental sciences seems to me to be a unique learning experience combining academic rigor with application to real current public projects that will change the environment. Your students are extremely fortunate at the undergraduate level to have this exposure which can point the way toward various professions. I hope your students choose a State Coastal Conservancy project to work on again.

Sincerely yours,

Peter S Brand

Peter S. Brand
Project Analyst

PSB/ds

cc: Paula Carrell

enclosure

State of California—
Resources Agency
Edmund G. Brown Jr.
Governor
1330 Broadway, Suite 1100
Oakland, California 94612
ATSS 561-1070
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STATE OF CALIFORNIA—STATE LANDS COMMISSION

EDMUND G. BROWN JR., Governor

STATE LANDS COMMISSION
1807 13TH STREET
SACRAMENTO, CALIFORNIA 95814
(916) 445-2682

October 14, 1982

File Ref: W22992
W23009

Doris Sloan
Lecturer in Environmental Sciences
Paleontology Department
University of California
Berkeley, CA 94720

Dear Doris:

I wish to take this opportunity to compliment you and your students upon the study report: "The East Bay Shoreline - Selected Environmental Issues" published in June 1982.

The quality of the presentations and scholorship standards are excellent in my view, and because of this, the report is of considerable aid to public agencies. I emphasize the scholorship aspect because during recent years, professionally prepared reports that have come to my attention indicate that research standards have slipped in some cases.

This report is cited in the State Lands Commission's study of the Albany Baylands; I will send you a copy as soon as it is received from the printers.

I look forward toward cooperating with you and your students in the future. Fruitful areas for additional research that could be performed by your students arise periodically, and as this occurs I will try to keep you informed.

Sincerely,

Kent Dedrick

KENT DEDRICK, Ph.D.
Research Program Specialist

KD:bq

STATE OF CALIFORNIA

EDMUND G. BROWN JR., Governor

SAN FRANCISCO BAY CONSERVATION AND DEVELOPMENT COMMISSION
30 VAN NESS AVENUE
SAN FRANCISCO, CALIFORNIA 94102
PHONE: 557-3686

August 31, 1982

Mr. W. B. N. Berry, Head Advisor
Environmental Studies Group Major
College of Letters and Science
Unverisity of California
Berkeley, California 94720

SUBJECT: The East Bay Shoreline: Selected Environmental Issues:
East Shoreline Park, BCDC Inquiry File No. AL.MC.8205.1

Dear Mr. Berry:

Dr. Doris Sloan and her senior seminar environmental science students have complied a very thorough and informative study of the East Bay Shoreline. The study presents an excellent overview of environmental issues in the area and will be useful to public agencies like ourselves who will be making funding and regulatory decisions there in the near future.

Very truly yours,

Nancy Wakeman

NANCY WAKEMAN
Senior Planner

NW/lg

Save San Francisco Bay Association
P.O. Box 925 • Berkeley, California 94701 • (415) 849-3053 • 849-3044

September 30, 1982

Melitta Beeson
Division of Special Programs
Environmental Sciences
301 Campbell
University of California
Berkeley, CA. 94720

Dear Melitta Beeson:

Enclosed is check $1059 for $150.00 for a contribution toward the printing of the Senior Seminar Report "Eastbay Shoreline".

I have heard high praise of the Report and I am anxious to read it.

Good luck with the sales!

Sincerely,

Esther Gulick

Mrs. Charles A. Gulick
Treasurer

16) 445-0835

OCT 0 6 1982

Regents of the University of California
University of California
Berkeley, California 94720

Regents of the University:

I am writing to express my appreciation of the effort taken by Doris Sloan of your university staff, and her senior Environmental Studies class, in the preparation of The East Bay Shoreline: Selected Environmental Issues (June 1982). This publication is an outstanding collection of reports, all of which exhibit a high degree of research and professionalism. It successfully pulls together and addresses several of the main issues affecting the shoreline into a truly useful resource document.

As you know, this Department's Planning staff is involved in the preparation of a feasibility study for the proposed East Bay Shoreline project, and has had the opportunity to interact with Ms. Sloan and her students on several occasions. Their participation has proved to be most productive and valuable. Indeed, such a program is a credit to the University of California Berkeley, and will hopefully continue to be so in the future.

Sincerely,

Original signed by
Ross Henry

Ross T. Henry, Chief
Statewide Planning and
Assistance Programs

RTH:BLegarra:fm

ERRATA

The Potential for Recreational Shellfish
Harvesting along the Brickyard Shoreline

P. 95, Paragraph #1: bed #15 and bed #16 should read bed #25 and bed #23 respectively.

P. 97, Paragraph #2: The first digit of the monetary figure has been omited. It should read $3,750,000.

P. 100, section entitled "Bacterial Standard for Shellfish Meat": The "$\leq$" less than or equal sign has been omitted from the MPN figure. It should read: $\leq$ 230/100 grams.

P. 106, Paragraph #1: 80 mg/100 gm should read 80μg/100 gm

P. 101, first line: sttempt should read attempt.

P. 111: $\text{MPN} = \dfrac{100 \text{ X } P}{\sqrt{N \text{ X } T}}$ not $\dfrac{100 \text{ X } P}{N \text{ X } T}$

The square root sign has been omitted in both formulas on this page.

THE EAST BAY SHORELINE
Selected Environmental Issues

Senior Seminar
Environmental Sciences Group Major
University of California, Berkeley

Doris Sloan, Editor
June 1982

ACKNOWLEDGMENTS

The members of the class wish to thank the following people for contributing their time and assistance to this project:

Stephen F. Bailey, Museum of Vertebrate Zoology, University of California, Berkeley, CA.

Fred Botti, Wildlife Biologist, California Dept. of Fish and Game, Yountville, CA.

Peter Brand, Project Analyst, State Coastal Conservancy, Oakland, CA.

Lynn Brenner, Manager, Parks Design Section, City of Berkeley, CA.

Phil V. Brylski, Museum of Vertebrate Zoology, University of California, Berkeley.

Kirk Chiapella, Recreation Coordinator, Aquatics, City of Berkeley, CA.

Howard L. Cogswell, Director, East Bay Regional Parks District, Oakland, CA.

Joanne Cox, Waste Management Specialist, Regional Water Quality Control Board, Oakland, CA.

Alan Craig, Endangered Wildlife Program, California Dept. of Fish and Game, Sacramento, CA.

George W. Domurat, Oceanographer, U.S. Army Corps of Engineers, San Francisco, CA.

Harvey E. Doner, Professor of Plant and Soil Biology, University of California, Berkeley.

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Deborah L. Jory, Department of Geography, University of California, Berkeley.

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Vince Spencer, Registered Sanitarian, Environmental Health Section, City of Berkeley, CA.

Catherine Sponseller, Environmental Protection Specialist, U.S. Army Corps of Engineers, San Francisco, CA.

John Sustar, Coastal Engineer, U.S. Army Corps of Engineers, San Francisco, CA.

Mark Trembley, CHNMB, San Francisco, CA.

Nancy Wakeman, Senior Planner, S.F. Bay Conservation and Development Commission, San Francisco, CA.

Marshall Walker, Urban Planner, City of Richmond, CA.

R.L. Wiegel, Professor of Hydraulic and Coastal Engineering, University of California, Berkeley.

Clarence Young, Supervising Sanitary Engineer, California Department of Health Services, Berkeley, CA.

STATEMENT ABOUT THE AUTHORS

This study was undertaken by seniors of the Environmental Studies Group Major at the University of California, Berkeley. The Environmental Studies Group Major offers three fields of specialization, physical science, biological science, and social science, from which the student selects an area of concentration. All members of the major participate in a two-quarter group study in their senior year. The purpose of the study is to provide members of the major with an opportunity to gain experience in the field work, general research practices, and group dynamics, as well as to examine practical environmental problems.

A study of The East Bay Shoreline was conducted by this seminar because we felt a more complete reference was needed to provide information upon which to base future decisions involving human intervention with the natural processes of the bay and adjacent marsh. It is hoped that this study will be useful to all those involved in these decisions and will increase the awareness of those previously uninformed about the vital functions of this natural resource.

The report was edited by Doris Sloan, and base maps were prepared by Allison Turner, unless otherwise indicated. The following students contributed both their time and effort to this project:

Don Bachman
Dexter Chan
Lisa Cohen
James K. Doyle
Mary H. Dresser
Grant Edelstone
Peter K. Gee
Linda Goad
Sharon D. Gray
Mary Hagman
Aaron E. Jeung
Bessie Lee
Arthur Molseed
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David Olson
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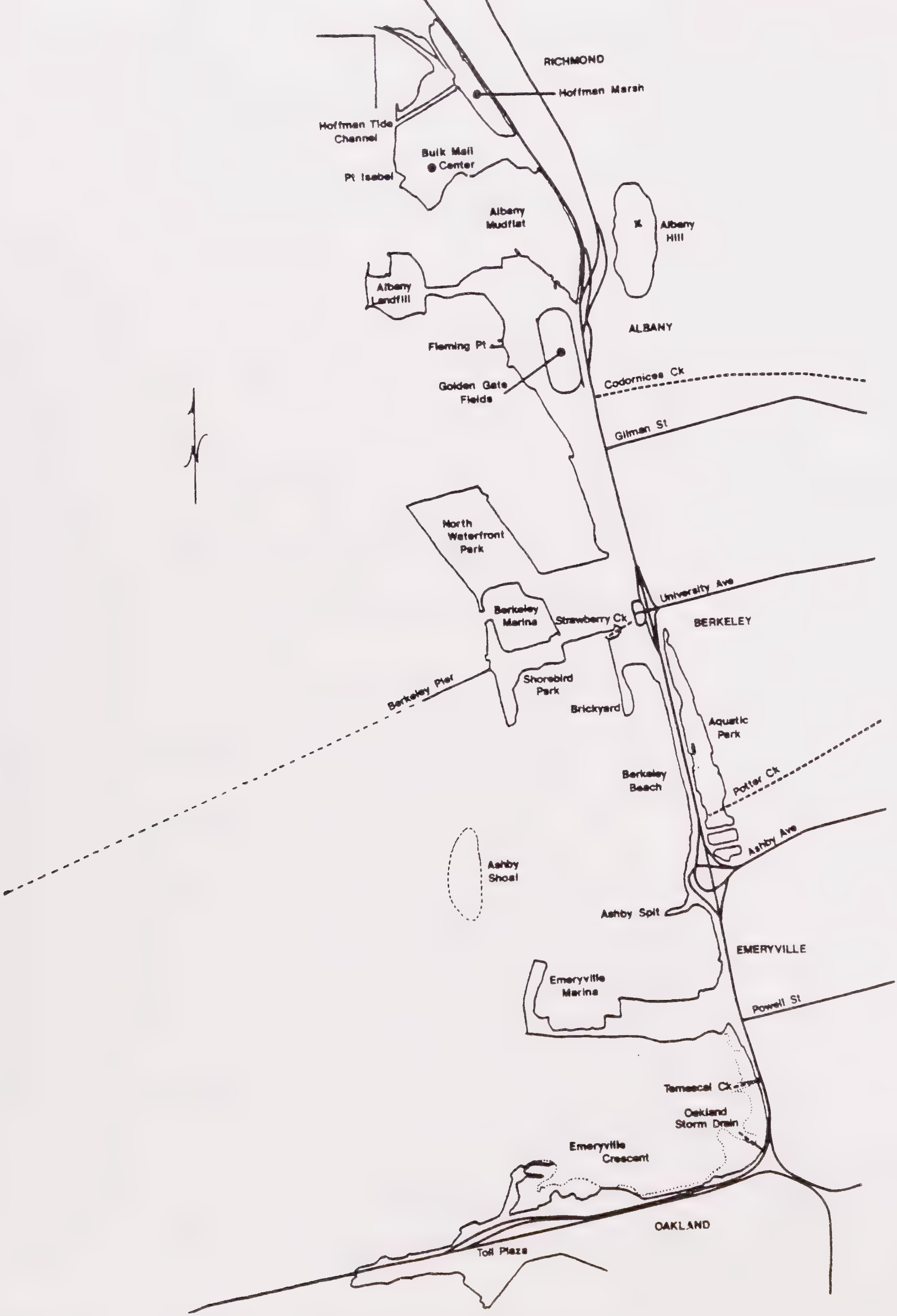

FRONTISPIECE. East Bay Shoreline, showing localities mentioned in report.

INTRODUCTION

The shoreline of San Francisco Bay from Emeryville to Albany has been proposed for a new state park. This waterfront, adjacent to the large urban populations of Alameda and Contra Costa Counties, has magnificent vistas across the bay and many opportunities for public access and recreational use.

The park potential of this area has been recognized by far-sighted citizens and organizations for several decades. With the passage in 1980 of the State Park Bond Act (Proposition 1), funds became available for land acquisition and park development. The shoreline from Emeryville to Albany was given top priority for Alameda County funds. In 1981 and 1982 the state Coastal Conservancy sponsored a series of public workshops to get citizen input into planning for the shoreline. In April 1982 the state Department of Parks and Recreation released a preliminary feasibility study that explored the possibility of acquiring and developing various areas along the shore. Many of its recommendations resulted from the public workshops.

The Department of Parks and Recreation recommended that (1) fee title should be acquired to all privately-owned shoreline properties from the Bay Bridge to the Contra Costa County line; (2) the Emeryville Crescent and Albany Mudflats be acquired and managed by the U.S. Fish and Wildlife Service or the state Department of Fish and Game with controlled public access; (3) a shoreline trail corridor be established linking the Albany peninsula with the Emeryville fill; and (4) studies be undertaken to determine the feasibility of beach restoration along the shore.

The state legislature has made the sum of $4,000,000 available in the 1982-83 state budget for the first phase of park development, which is proposed to include the Brickyard area and the waterfront from University Avenue to Emeryville.

The 1981-82 Senior Seminar in Environmental Sciences chose the East Bay Shoreline as its topic because of the importance and timeliness of the park proposal. Furthermore, the need for more detailed information on many aspects of the shoreline became clear during the public hearings. Our report addresses biological, social and physical questions, reflecting the three emphases of the Environmental Sciences major. Specific reports deal with water quality, stability of the shoreline, access, preservation of vital marsh habitat, zoning and questions of land use. We hope that our report answers some of the questions which have been raised about the shoreline and contributes to the development of a park along this important waterfront.

SECTION I: OVERVIEW OF THE SHORELINE

Chapter 1

THE POTENTIAL FOR AN EAST BAY SHORELINE PARK: THE ROLE OF THE EAST BAY CITIES IN LAND USE

Mary Hagman

Introduction

The State Department of Parks and Recreation (DPR) has offered to the citizens of Albany, Berkeley, Emeryville and Oakland a solid proposal for an East Bay Shoreline Park (DPR, 1982). The park proposal recommends public acquisition of some 940 acres along the nine-mile stretch of shoreline which borders these four cities and suggests potential uses such as camping, pedestrial and bicycle trails, swimming areas, boating facilities and wildlife reserves. Although DPR engineered the draft plan, it relied heavily on the findings of the State Coastal Conservancy which, since January 1981, has called on the services of consultants, private interest groups and concerned citizens to help in the planning process.

Now we have a plan. The park, however, remains a dream. If we want an East Bay Shoreline Park, we, the citizens, must step forth and make our desires known. Most people would agree that preservation of open space is desirable, both to guard precious natural resources and also to provide much needed open space for outdoor recreation. Yet, the question of how much open space is desirable and economical causes many a heated debate. When open space is eventually set aside, often it is due to great public support and pressure. The only realistic chance that the proposed East Bay Shoreline Park has is if organizations such as Save the San Francisco Bay Association and the Audubon Society, as well as the general public, rally in an organized fashion and pressure the cities and Santa Fe Land, Inc. into meeting our needs. If we want a park, we should support the efforts of DPR to see that all the planning done thus far is not completely lost. Grassroots action now will enhance the East Bay shoreline for the use and enjoyment of generations to come.

Albany, Berkeley, Emeryville and Oakland are our cities. We are the citizens. As citizens, we need to work together with city officials to make our needs and desires known. The issues involved in the proposed East Bay Shoreline Park are

basically land use issues. Much control rests with the cities with respect to land use within their jurisdictions. If we are to work with the city officials, understanding how land use is regulated by the cities will be helpful. In this paper, we will explore the basic laws regarding the city's role in land use control. Then we will look at the specific areas in each city that are within the proposed East Bay Shoreline Park. Finally, we will focus on current and proposed land uses. By doing so, we hope to be better equipped to participate effectively in our city governments and to push for the East Bay Shoreline Park.

Agencies with Land Use Control in the East Bay Shoreline Park Area

Before looking at the role of the cities, we must define specifically which agencies have land use control in the project area. For the most part, the cities have direct control over land use within their boundaries. However, two additional agencies, the San Francisco Bay Conservation and Development Commission (BCDC) and the Corps of Engineers govern specific shoreline areas within the cities.

Created in 1965 by the McAteer-Petris Act, BCDC is a state planning and regulatory agency. BCDC's jurisdiction covers San Francisco, Suisun and San Pablo Bays, specific tributaries and creeks, all sloughs of the bay system and the area of land 100 feet inland from the bay (Jones and Stokes, 1979). The McAteer-Petris Act empowers BCDC to:

> issue or deny permits, after public hearings, for any proposed project that involves placing fill, extracting material or making any substantial change in the use of any water, land or structure within the area of the Commission's jurisdiction.

BCDC was created primarily to protect the bay for the use and pleasure of future generations. Along the East Bay shoreline, BCDC's jurisdiction includes only the land up to 100 feet from the mean high tide and also the land along the banks of creeks 100 feet inland from the line of highest tidal action. Projects in the bay are often initially reviewed by BCDC and then further inspected by the second agency with control, the Corps of Engineers (Phillips, 1982, pers. comm.).

The Corps of Engineers is a federal agency. Its main responsibility is for the waterways, but its jurisdiction also includes all land and water up to the mean high water line. Therefore, any project affecting the water or wetlands must be approved by the Corps, including all dredging and filling activities (Jones and Stokes, 1979).

Within their jurisdictions, BCDC and the Corps of Engineers may negate any planning permits issued by a local municipality if the permit authorizes an

unacceptable use. Yet all land 100 feet from the shoreline and landward remains under the direct control of the cities. Additional agencies such as the U.S. Fish and Wildlife Service and the California Department of Fish and Game play only advisory roles with respect to land use along the shoreline.

The Cities - Their Organization and Land Use Authority as Local Regulatory Agencies

A city may be incorporated as either a charter or a general law city. Of the cities in which we are interested, only Emeryville is of the latter type. As a general law city, Emeryville must accept the powers entrusted to a general law city as mandated by the state constitution, and is always subject to state law if the state chooses to intervene in a local affair. As charter cities, however, Albany, Berkeley and Oakland differ from Emeryville in two main ways. First, each of these cities must adopt a charter and in doing so they can limit their own power. Secondly, a charter city enjoys the so-called "shield effect," which means that city regulation always supercedes state law with respect to local affairs (Hagman, 1982). In actuality, the differences between charter and general law cities do not affect the functioning of the city to any great degree. Understanding the differences, however, will be helpful as we turn to study the authority vested in cities and its relationship to land use. We will see subtle variations, depending on whether the city is incorporated as a general law or charter city.

The principle of police power entrusts governments to legislate for the health, morals, safety and general welfare of the community (Wright and Webber, 1978). In California the state constitution specifically grants this power to both charter and general law cities through the doctrine of home rule (Curtin, 1981). Under Art. XI, paragraph 7:

> A county or city may make and enforce within its limits all local, police, sanitary and other ordinances and regulations not in conflict with general law.*

Basically, home rule allows cities to act on their police power. With respect to land use, the doctrine of home rule allows cities to exercise their police power in the areas of planning and zoning. This power may be practiced even though it may hinder the use and enjoyment of private property.

Home rule affords cities the freedom to regulate but also confers on them the responsibility to govern in the best interest of the citizens. Land use control

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*Article XI, paragraph 7 covers both charter and general law cities. Home rule power with respect to charter cities is also covered in Article XI, paragraph 5 and Article XI, paragraph 7a.

is a major responsibility of the cities. To help insure that land use is regulated in the best interest of the community, state planning law mandates that "each city shall adopt a comprehensive, long-term general plan for the physical development of the county or city, and any land outside its boundaries which in the planning agency's judgment bears relation to its planning" (California Government Code, paragraph 65300). The general plan is to serve as "a constitution for all future development within the city . . ." as stated by the court in O'Loane v. O'Rourke 231 Cal. App. 2d 774, 782 (1965).

As the "constitution" regulating municipal land use, state law further decrees that the general plan must have nine mandatory elements addressing concerns such as housing, seismic safety, and noise (California Government Code, paragraph 65302). The general plan elements, however, that are of particular relevance to the preservation of open space and wildlife are the land use element, the conservation element and the open space element. The land use element designates the proposed general distribution, location and extent of the uses of the land (California Government Code, paragraph 65302). The conservation element concerns the conservation, development and utilization of natural resources and the open space element defines the lands to be preserved for open-space use (California Government Code, paragraphs 65302, 65560). With respect to the potential for the proposed East Bay Shoreline Park, these elements of the general plans of Albany, Berkeley, Emeryville and Oakland are of particular importance in judging each city's desired goals for the land along the bay within its jurisdiction.

The policies and goals set forth in the general plan are regulated by the zoning ordinance. Zoning may be defined as the "legislative division of the community into areas in each of which only certain designated uses are permitted so that the community may develop in an orderly manner" in accordance with the general plan (Riggs and Smith, 1974). As a matter of course, cities adopt general zoning ordinances, although state law only requires them to have a few specific zoning codes. The state law on zoning varies depending on whether a city is a general law or charter city. Whatever zoning is adopted by a general law city must comply to the State Zoning Law. Charter cities are exempt from most of the zoning laws (Hagman, 1982). For our purposes, however, it is important to note that open space zoning is required of both charter and general law cities. Section 65910 of the California Government Code reads:

> Every city and county by December 13, 1973, shall prepare and adopt an open-space zoning ordinance consistent with the local open-space plan . . .

In summary, all cities must have both an open space element as part of the general plan, and the open space zoning ordinance must be compatible with the objectives and policies set forth in the plan.

The Cities Involved--Their Land Use Policies

In this section, we will take an individual look at the status of the proposed park areas within the cities of Emeryville, Albany and Berkeley.* Zoning classifications and land ownership boundaries along the East Bay shoreline are presented in FIGURES 1 and 2.

Emeryville

The City of Emeryville has followed a pro-development strategy. Thus, most of the land west of Interstate-80 has been developed under a Planned Unit Development (PUD) zoning regulation allowing for commercial, residential and marina uses. Additional development is scheduled to take place within the PUD zone and will include building of two towers, a conference center adjacent to the Holiday Inn and expansion and improvement of the existing marina (Masterson, 1982, pers. comm.).

The remaining land of concern within Emeryville is zoned residential, the most restrictive zone in Emeryville. The city's zoning ordinance does not specify an open space zone at this point, but city officials are working on complying with the state law regarding open space zoning as stated above. At present, all the land within the residential zone is open space and although privately-owned development for uses other than recreational activities is highly unlikely. The areas in question are relatively small and any substantial development would require filling. Most of the land, however, is within BCDC's jurisdiction, and permits for filling or for uses other than for open space probably would not be granted. Furthermore, the city's general plan sets forth the policy to "protect and maintain the shoreline for recreation and open space" (Emeryville Redevelopment Agency, 1979, p. 65). Although general plans are sometimes overlooked when development interests are attractive, city officials express commitment to this policy. In addition, restrictions already discussed in effect dictate such a policy.

The open space of concern may be divided into three areas: the Emeryville Fill Southern Shoreline, the land between Powell Street and the Emeryville Crescent;

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*A short discussion of the area in Oakland is included within the section on Emeryville.

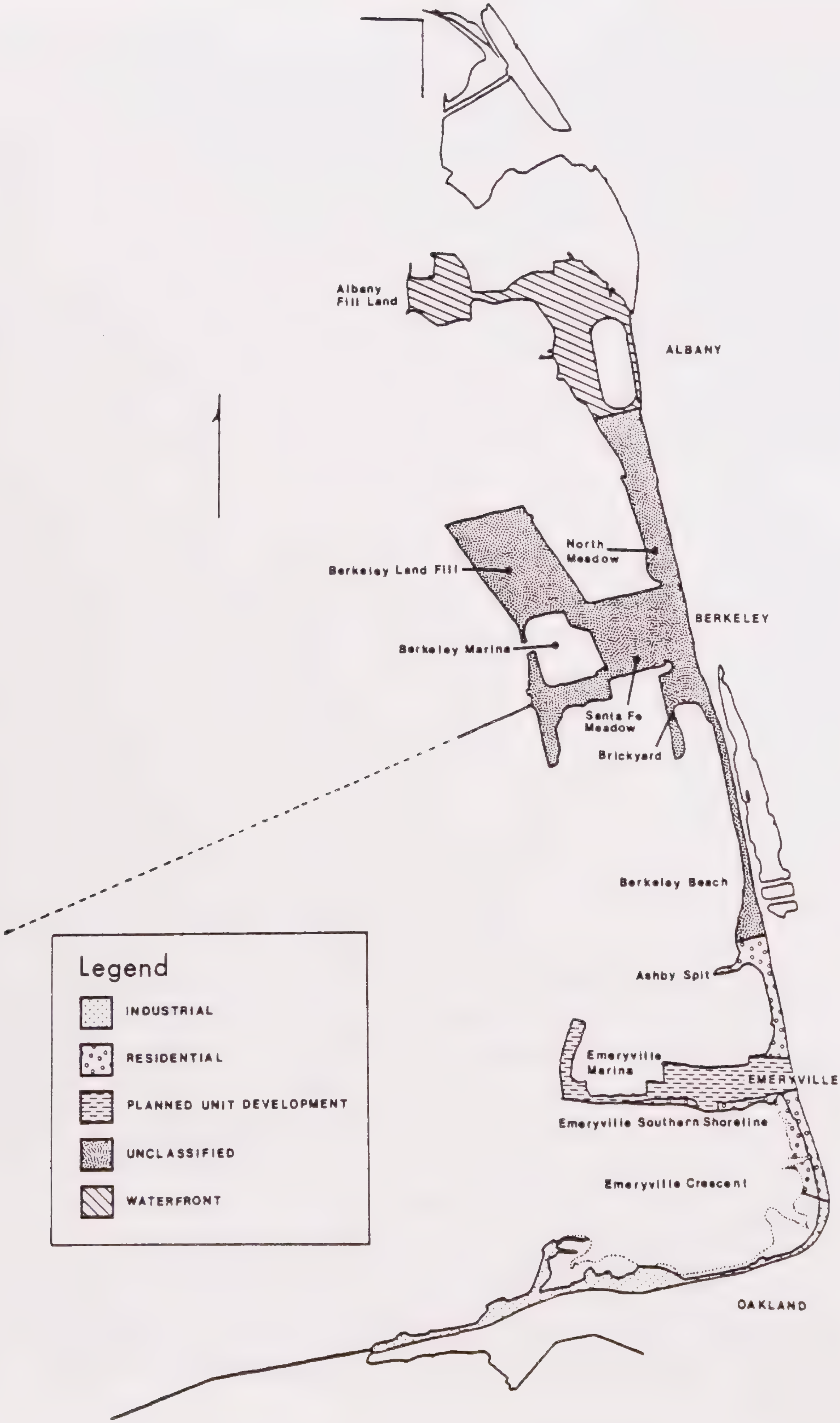


Figure 1. Zoning Classification along the East Bay Shoreline.

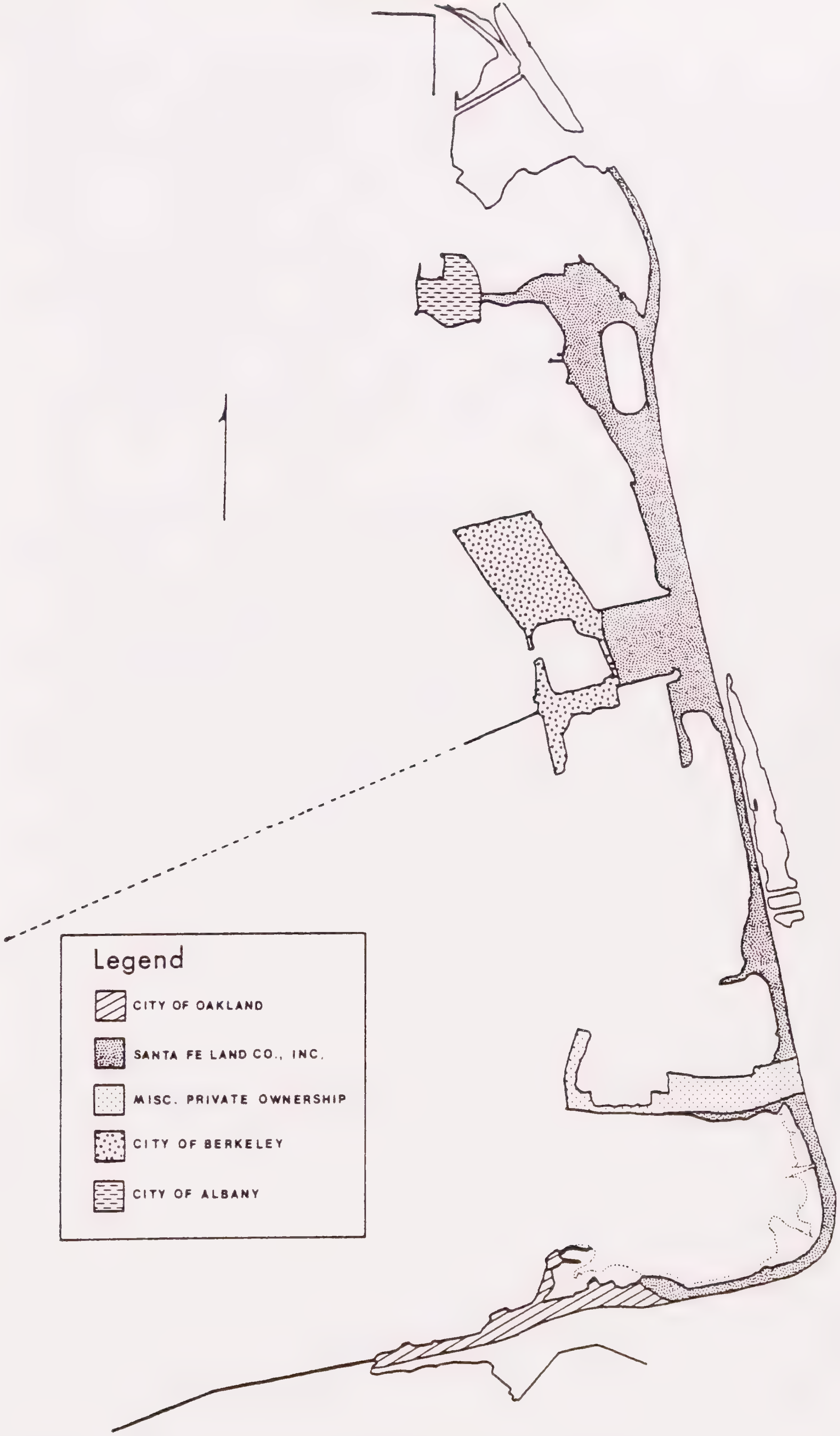


Figure 2. Land Ownership along the East Bay Shoreline.

the strip north of the fill, including the Ashby Spit; and the Emeryville Crescent (FIGURE 1). Currently, the city must landscape the strip east and west of the city hall, the Emeryville Fill Southern Shoreline. It is being required to do so by BCDC as part of a public benefit program in order to "redeem" the city for having dumped 7.5 acres of unauthorized fill into the bay. The city has no specific plans regarding either the shoreline area north of the peninsula including the Ashby Spit or the Emeryville Crescent (Fong, 1982, pers. comm.). The general plan does suggest that public acquisition of the private lands is desirable and that controls should be developed "in the use of the 'Crescent' area to preserve the existing wildlife and natural features" (Emeryville Redevelopment Agency, 1979, p. 66).

The East Bay Shoreline Park proposal includes additional uses for the residential zone areas. For the Emeryville Fill Southern Shoreline, DPR suggests that the strip would be ideal for a pedestrian and bicycle trail. A trail is also suggested for the strip just north of the Emeryville landfill. This strip ends at the Ashby Spit, a 3.5 acre jetty which is currently used primarily for fishing and the harvesting of clams. The DPR plan suggests that the Spit should be developed to allow greater access and suggests that a small parking facility, restrooms, and a viewing area would be desirable. This northern strip and the Ashby Spit are included for priority land acquisition under the DPR proposal.

With respect to the Emeryville Crescent, DPR agrees with the city that access to the area should be limited to protect the valuable wetlands. It should be noted here that a good part of the Crescent lies within the City of Oakland. Although the area in Oakland is zoned industrial, the use of this land is restricted by BCDC and thus is subject to the limitations already discussed with respect to the Crescent area in Emeryville. (For further information on the Emeryville Crescent, please refer to papers by Lisa Cohen, Jim Doyle and David Olson.)

The park development process has not yet reached the point where DPR and the City of Emeryville have participated in joint planning sessions. It seems, however, that the DPR plans are consistent with the goals of Emeryville and thus, coordination between the two should not be too difficult.

Albany

The City of Albany has spent years struggling with its waterfront lands, but in February of 1977 the city council adopted the Albany Waterfront Planning and Feasibility Study, often referred to as the Environs Plan (Colby, 1977). In

addition to the city council, the plan is supported by the Albany city planners and the Albany Citizens Waterfront Committee (Guletz, Arnold, 1982, pers. comm.). Furthermore, the plan has been adopted as the DPR plan for Albany. The support for the Environs Plan is documented in the Albany general plan which was revised in March of 1980 to include recognition of the plan. Also, the zoning of the area as "waterfront" with such designated uses as commercial recreation, marina facilities and swimming areas is consistent with the general plan.

. The concensus and great enthusiasm behind the Environs Plan is vital to its survival, yet many obstacles must still be overcome if the plan is to be implemented. The 30 acre Albany Land Fill is publicly owned, but thus far the dump has not been closed. At present, a court case over who is responsible for the dump closure is in litigation. If the dump operator is not found liable for closure, the City of Albany will need financial help to pay for closure (Rotramel, 1982, pers. comm.). Only after the dump is closed can development of the marina and other recreational facilities included in the Environs Plan begin.

Even if the dump operator is found liable for closure, the City of Albany will remain extremely short of funds for the plan. For full implementation of the Environs Plan, much additional money will be necessary for acquiring privately-owned land and for developing facilities. Approximately 10 acres of undeveloped lands in the waterfront area are privately owned by Santa Fe. Although there is a public easement over the Santa Fe Land Fill area, acquisition of this land would be desirable to allow for a continuous recreational area from Interstate 80 to the Albany Land Fill. Furthermore, funds would be needed for the marina, fishing facilities, picnic areas, trailer sites and other recreational uses.

Obviously, then, difficulties do exist and much work and coordination will be necessary to see the Environs Plan implemented. Given the support for the plan, however, the potential for recreational development is good, especially considering that DPR has respected Albany's wishes in its proposal and that the City of Albany is willing to cooperate with DPR in order to see the plan become a reality.

Center

Although development of recreational facilities in both Emeryville and Albany will require much additional work, at least there exists a fair concensus on goals for the areas and a desire to see the plans implemented. The situation in the City of Berkeley, however, is a great deal more complex and sensitive.* The

*Due to the sensitive nature of the shoreline issue in Berkeley, sources of information will not be disclosed.

shoreline area within Berkeley's jurisdiction may be divided into the following six parcels (FIGURE 1): (1) Berkeley Beach, 7± acres; (2) Brickyard, 27± acres; (3) Santa Fe Meadow, 71± acres; (4) North Meadow, 37± acres; (5) Berkeley Marina, 3± acres; (6) Berkeley Land Fill, 90± acres. The first four areas are owned by Santa Fe Land, Inc., while the remaining two are owned by the City of Berkeley.

The city has approved plans for the two areas it owns. The Berkeley Marina is already developed and includes the harbor area plus other recreational facilities such as a fishing pier, picnic areas and restaurants. The Berkeley Land Fill has yet to be completely closed, but development of 10 acres of the fill as the North Waterfront Park has been completed, with work on an additional 10 acres to begin in the fall of 1982. (See paper by Sharon Gray for further discussion of the Berkeley Land Fill.) The rest of the shoreline area, owned by Santa Fe, remains vacant.

For years the City of Berkeley and Santa Fe Land, Inc. have been at odds over potential use of the Santa Fe lands. The entire shoreline, including the areas owned by Santa Fe, is zoned unclassified, which allows "all uses not otherwise permitted by law provided that a use permit shall be secured for any use to be established in the unclassified district" (City of Berkeley, 1977, p. 59).* Thus far, Berkeley, has not issued any use permits to Santa Fe. In 1972, Santa Fe sued the City of Berkeley on an inverse condemnation charge regarding the Santa Fe Meadow portion of its land. A private owner may claim inverse condemnation when regulations over private property are employed in an arbitrary, capricious or unreasonable way such that the regulation interferes with the fair use of the land by the owner. Recently, Santa Fe lost on the inverse condemnation charge, but some issues have yet to be resolved.

Because some issues are still in litigation, discussion of the area with Berkeley city officials or with Santa Fe is virtually impossible. Neither party can afford to say much about the land, as it could potentially jeopardize its case. Santa Fe, in particular, has kept very silent. Several City of Berkeley officials have expressed dissatisfaction with the DPR proposal and feel that the interests of the city were not considered fully. They are far from committing themselves on such developments as a conference center on Santa Fe Meadows or a campground in the North Waterfront Park as proposed in the DPR plan. It does seem, however, that city officials would allow some commercial development of the Santa Fe lands but only with close supervision and permission from the city. (See paper by Sharon

*Uses otherwise prohibited by law would include such establishments as casinos or houses of prostitution.

Gray on the North Waterfront Park and paper by Debbie Brown on the Brickyard. Many of the issues, especially with respect to the Brickyard, are the same throughout the area. Also see papers by Don Bachman, Peter Gee and Linda Goad for information on the Berkeley Beach area.)

As a way to circumvent the inherent difficulties in dealing with public and private sector interests, DPR has suggested direct acquisition of the Santa Fe land. Unfortunately, money for land acquisition is severely limited, and furthermore, Santa Fe does not seem interested in selling its land. DPR has also suggested that an option for the land could be negotiated, but again Santa Fe may not be willing to cooperate.*

It may be, however, that direct acquisition of the land is neither the most desirable, nor realistic nor economical manner in which to handle the shoreline area. In the past, efforts on the part of Santa Fe and the City of Berkeley to work together have not been particularly successful. Yet, along many California shoreline areas, the public and private sectors have come together and negotiated development projects acceptable to all concerned parties. Many of the project negotiations have been directed by the State Coastal Conservancy. For example, the Aliso Greenbelt Plan covers an area of 5,300 acres along the Southern California shoreline. Fifteen percent of the land involved will be developed with revenue-generating uses to support the remaining 85 percent, which is to be maintained for open space and recreational activities (State Coastal Conservancy, 1982). The Coastal Conservancy was involved in another project, the Los Cerritos Wetlands in Los Angeles County. In that area, dry fill land and wetlands are mixed, but much development pressure exists. At present, however, a plan is being worked out in which the fill lands will be consolidated to allow for development, but the rest of the area is to be restored to a productive wetland habitat (State Coastal Conservancy, 1982). These examples are cited to illustrate that public and private parties can work together and develop projects which are of general benefit.

With respect to the shoreline areas within Berkeley, perhaps similar discussions and coordination, possibly mediated by the State Coastal Conservancy, could help city officials, the citizens and Santa Fe come to an agreement on development of the area. At this point, it does seem that some development of the area is probable--Santa Fe certainly wants to develop in some way, the City of Berkeley feels that

*Taking an option on land means that an agreement has been reached between the owner and a potential buyer in which the buyer obtains the sole right to buy the land within a specified time period. In the shoreline area, taking an option would essentially buy time to find the money for direct acquisition.

development would generate much needed revenue and money for acquisition of the whole area is simply not available. Projection of the possible outcome of negotiation is beyond the scope of this paper. However, we will now examine two zoning measures, namely, Planned Unit Development (PUD) and density transfers, which might be utilized in this negotiating process.

PUD ordinances are becoming more and more popular, as they allow for various compatible uses within the same area (Riggs and Smith, 1974). PUD stands in contrast to traditional zoning which designates an area for a single use--such as residential, commercial, or industrial. In a PUD zone, the city can determine the uses to be permitted and also can regulate such factors as height of buildings, parking restrictions and open space requirements. Basically, PUD would allow for the entire shoreline area to be considered, and thus for compatible uses to be established on neighboring parcels. It should be noted that the PUD area in Emeryville is not indicative of the potential that PUD has for setting aside open areas and for controlling development. High-rise buildings and large condominium complexes are not necessarily the compromises given for open space.

Density transfer is another means of setting aside valuable open space. In density transfer ordinances, property owners are given the opportunity to recoup the value of a site which is desired for open space use by allowing higher density development in another area. Possibly an arrangement could be made in which Santa Fe Land, Inc. would be allowed to build with higher density in a designated area with the agreement that another area would be developed for recreational use, or possibly, land most desired for open space could be dedicated to the public in exchange for development rights. In such arrangements, the types of uses in the areas to be developed are certainly negotiable. Basically, both PUD and density transfer could serve as tools for compromise to help put as much land as possible under public control especially given the limited amount of resources available for acquisition of land.

Conclusion

Private sector interests. Zoning ordinances. Value of land in question. General plan policies. Open space desires. Current land restrictions. Law suits. All of these factors are involved in land use questions along the East Bay shoreline. The more factors involved in any particular question, the more difficult it will be to consolidate the concerned interests and to go forth with a positive land use policy.

Although the concept that the more factors involved will require more negotiation is very straightforward, it helps to explain why we see such differences in the present situations in Albany, Berkeley, Emeryville and Oakland. As we have seen, the issue of the shoreline area in Emeryville and Oakland is fairly clear cut. The open space areas are not of high value and current land restrictions rule out the possibility of development. In sharp contrast, however, the situation in Berkeley involves a complicated mix of all of the above factors, including strong private sector interests, zoning restrictions and high land values. The situation in Albany lies somewhere in between. Some private sector interests and a law suit do complicate the picture, yet a firm concensus has been reached for a majority of the land in question.

At some point, however, the situations in Emeryville and Albany were as complicated as the issues involved in the Berkeley shoreline today. Emeryville chose to develop high-density commercial and residential complexes; Albany has set the land aside for commercial recreational uses. We must see to it that the remaining open space in Emeryville be developed for recreational use. We must help to pressure potential money sources to assist Albany in beginning recreational development of the Albany Land Fill and to acquire privately-owned land. Most of all, however, we should direct our maximum attention to the shoreline area in Berkeley. If we want most of the land set aside for open space, we need to commit ourselves to working with city officials and other interests to see that this end is met.

The fate of the East Bay Shoreline Park rests largely in our hands. We the citizens must make our desires heard.

REFERENCES CITED

Arnold, Bruce, Chairman, Albany Citizens Waterfront Committee, personal communication, 1982.

City of Berkeley, 1971. Zoning Ordinance: Berkeley, California, City of Berkeley, Ordinance no. 3018-NS, 135 pp.

Colby, Norman, February 15, 1977. Albany OK's Master Plan for Marina: The Independent and Gazette, p. 1.

Curtin, Daniel J., 1981. California Planning Law and Land-Use Regulations: A Legal Summary and Guide for Planning Commissioners, Members of Local Legislative Bodies and Staff: Berkeley, California, Continuing Education in Public Policy and Planning, University Extension, 69 pp.

Emeryville Redevelopment Agency, 1979. Emeryville General Plan: Emeryville, California, Vol. I, 66 pp.

Fong, Leslie, Assistant Planner, City of Emeryville, personal communication, 1982.

(continued)

REFERENCES CITED

(continued)

Guletz, Bob, Director of Public Works, Albany Planning Department, personal communication, 1982.

Hagman, Donald G., 1982. Just Plain Zoning: Irvine, California, University Extension, 140 pp.

Jones & Stokes Associates, Inc., 1979. Protection and Restoration of San Francisco Bay: Fish and Wildlife Habitat: San Francisco, California, U.S. Fish and Wildlife Service, California Department of Fish and Game, 87 pp.

Masterson, Bill, Chief Engineering Technician, City of Emeryville, personal communication, 1982.

Phillips, Rhonda, Permit Enforcement Staff, S.F. Bay Conservation and Development Commission, personal communication, 1982.

Riggs, Durward S., and Edward Ellis Smith, Eds., 1974. Land Use, Open Space, and the Governmental Process: The San Francisco Bay Area Experience: New York, New York, Praeger Publishers, 197 pp.

Rotramel, Anne, Albany City Councilmember, Albany City Council, personal communication, 1982.

State Coastal Conservancy, 1982. State Coastal Conservancy Annual Report: California, State of California, 28 pp.

State Department of Parks and Recreation (DPR), 1982. East Bay Shoreline Feasibility Study: California, State Department of Parks and Recreation, 61 pp.

Wright, Robert R., and Susan Webber, 1978. Land Use in a Nut Shell: St. Paul, Minnesota, West Publishing Company, 316 pp.

Chapter 2

HISTORICAL SHORELINE CHANGES:

NATURAL AND ARTIFICIAL

Allison Turner

Introduction

The East Bay shoreline has undergone many changes since the 1850'a due to the introduction of land fill and piers by man, and the resulting natural reactions, such as shallowing waters and growth of marsh. A description of these changes, as determined from aerial photographs, nautical charts and historical maps, is presented here.

Little of the shoreline under consideration is original (FIGURE 1). For the most part, this is due to man-made land fill, which has extended the shore an average of over 1000 feet (300 meters) into the bay from its original (1850's) position. Construction of piers and marinas has also caused major changes in current, wave and siltation patterns, beach placement, and marsh growth.

Wave and Current Theory

The extension of a land mass into bay waters has an effect on current and wave patterns, and thus on sedimentation patterns. Newly-introduced points of land will obviously affect local currents; they can also alter the direction of, or completely block, incoming waves. The direction and strength of waves (and of currents) is important to the stability of beaches and marshes.

Waves approaching the shore at an angle have a tendency to refract, becoming more parallel with the shore as the water becomes shallower. The portion of the wave's energy that was not directed toward the shore, but rather along it, is transferred into a current which runs parallel to the shore. This is known as a longshore or littoral current (FIGURE 2), and it carries sediment and debris with it down the shore (longshore drift). To prevent this movement of sand (and ultimately its total removal, if there is no replacement), groins can be placed out into the water to trap the sand as it goes by (FIGURE 3).

If a structure is built into water such that waves are completely stopped, or if a protecting headland is already present, the region behind the headland will

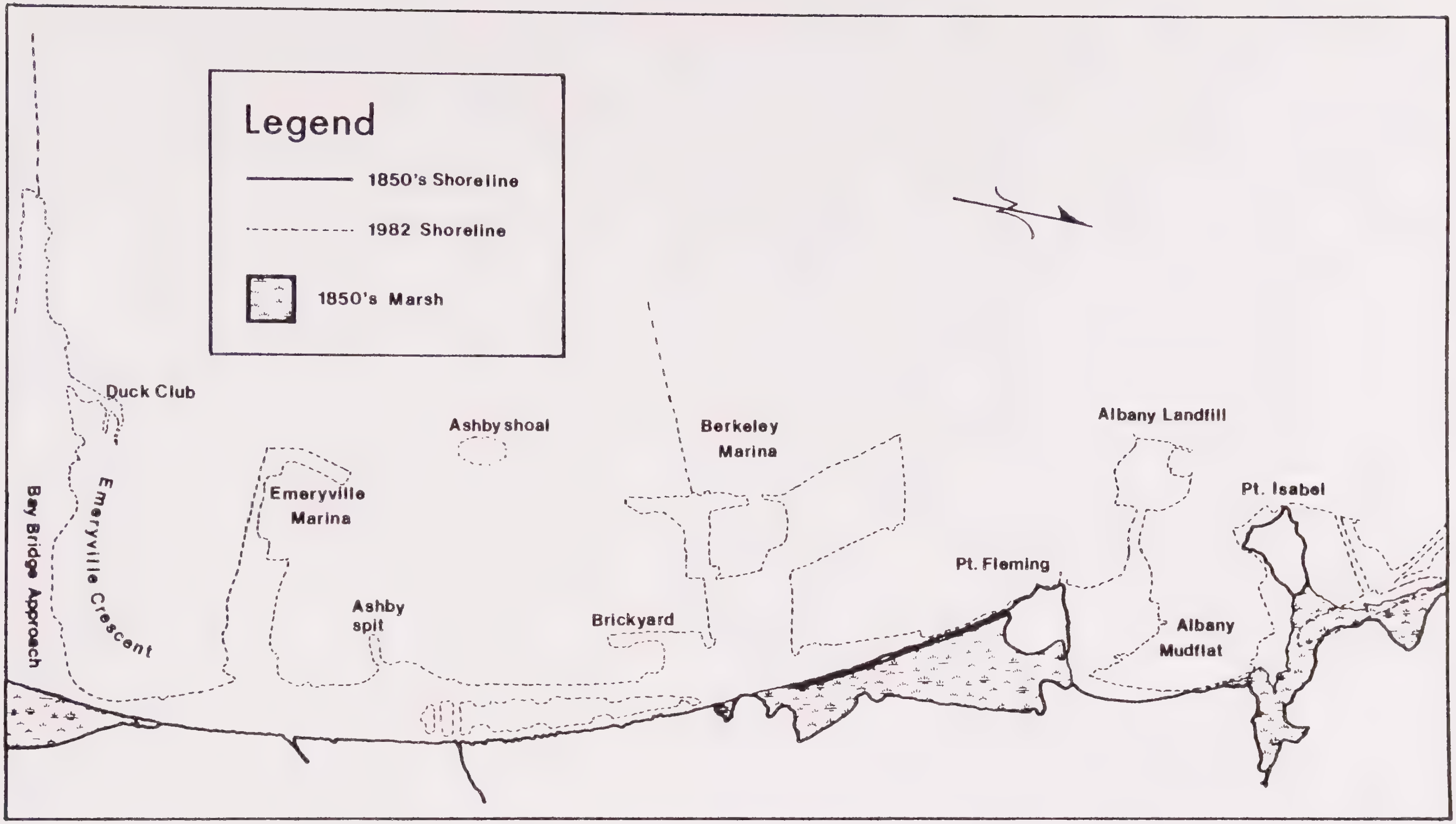


FIGURE 1. The Original East Bay Shoreline. (See FIGURE 5 for approximate dates of fill.)

Source: Nichols and Wright, 1971.

slope gradually as sediment accumulates in these calmer waters, and unprotected shores will drop off more steeply. Thus, any introduced fill which projects into the water could have one of two effects. Either sand will build up on the down-current side, and be removed to some extent up-current, as shown in FIGURE 3, or if the fill is in such a form that it protects the shore from waves almost entirely, sediment will slowly build up in the area behind the fill, making a shallow, gradual slope: a mudflat and, if left long enough with appropriate tidal action, a marsh (Bascom, 1964; Friedman and Sanders, 1978). My research examines the East Bay shoreline for changes such as these.

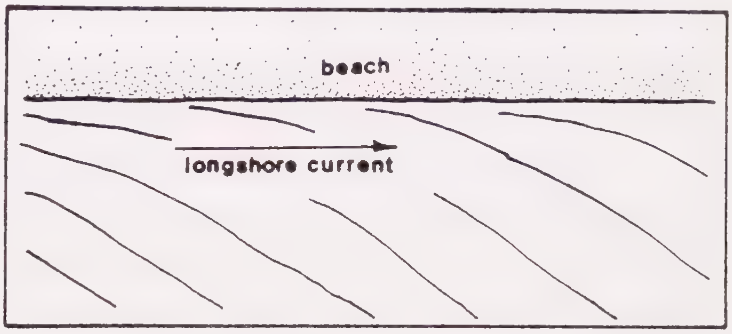


FIGURE 2. Littoral Current produced by waves.

Source: Bascom, 1964; Friedman and Sanders, 1978.

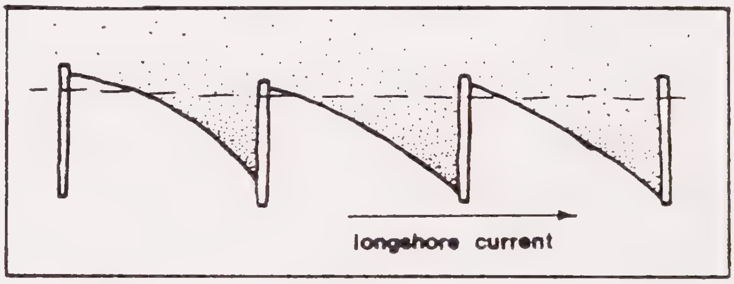


FIGURE 3. Groins reduce longshore movement of sediment.

Source: Bascom, 1964; Friedman and Sanders, 1978.

<u>Sources and Methods of Examining Data</u>

Three different resources were used to obtain data: 25 nautical charts (1903 to 1981), 93 aerial photographs (1931 to 1981), and one historical map (1850's; Nichols and Wright, 1971) (Appendix A). Each of these resources has specific advantages and limitations.

Nautical charts are available for many years and have both depth recordings and an accurate coastline, but do not include wave direction or currents. (Tidal current charts are available, but currents are not given in enough detail to be of value in this study.) Aerial photographs often show waves, but depths are quite difficult to determine, especially in San Francisco Bay where the water is too muddy for direct measurement (see Lundahl, 1948, for discussion of direct measurement of water depth from aerial photographs).

Aerial photographs often do not cover the entire area under consideration, and photos for early dates are not available. In addition, they are occasionally of such a small scale that measurements are difficult to make, and the division between

land, marsh and mudflat is sometimes difficult to see. They do, however, give a very accurate description of the land/water division around land fill which has steeply sloping shoreline (where differences due to tides are not extensive). Since most aerial photographs are taken from an approximately vertical position (straight up), all distances on the photograph are to the same scale. Oblique angle photographs do not have this advantage, presenting instead a panoramic view. These photographs are valuable for qualitative information only; distances and areas are almost impossible to measure accurately.

Aerial photographs have a record of marsh, beach and mudflat, which nautical charts do not, and historical maps have only occasionally. Dates for aerial photographs are more accurate, as days and often even the time are recorded directly on the photo. Maps and nautical charts are accurate only within a year at best, as data are compiled over a span of time before publication. Historical maps have many limitations, including all of those described for nautical charts. In addition, they do not have depth recordings and their coastlines are possibly less accurate, especially on older maps.

The data obtained from these sources are not in a readily usable form. Distances and areas measured from photos and maps must be converted to true distances using the scale of the map or photo. In cases where a scale is not recorded on a photograph (usually the case, unless the photo was enlarged or reduced to fit a specific scale), the distance between two prominent objects must be measured on the photograph and compared with the same distance on a map, and a scale calculated. With aerial photographs, wavelengths measured may be converted to water depths, as long as one depth is known to a reasonable accuracy for each set of photographs. (This depth can be obtained from nautical charts.) The formula for this conversion is

$$T^2 = \frac{2\pi\lambda}{g} \cot h \frac{2\pi d}{\lambda} \quad \text{(Lundahl, 1948)}$$

See Appendix B for additional discussion and actual calculations.

<u>East Bay Shoreline Changes</u>

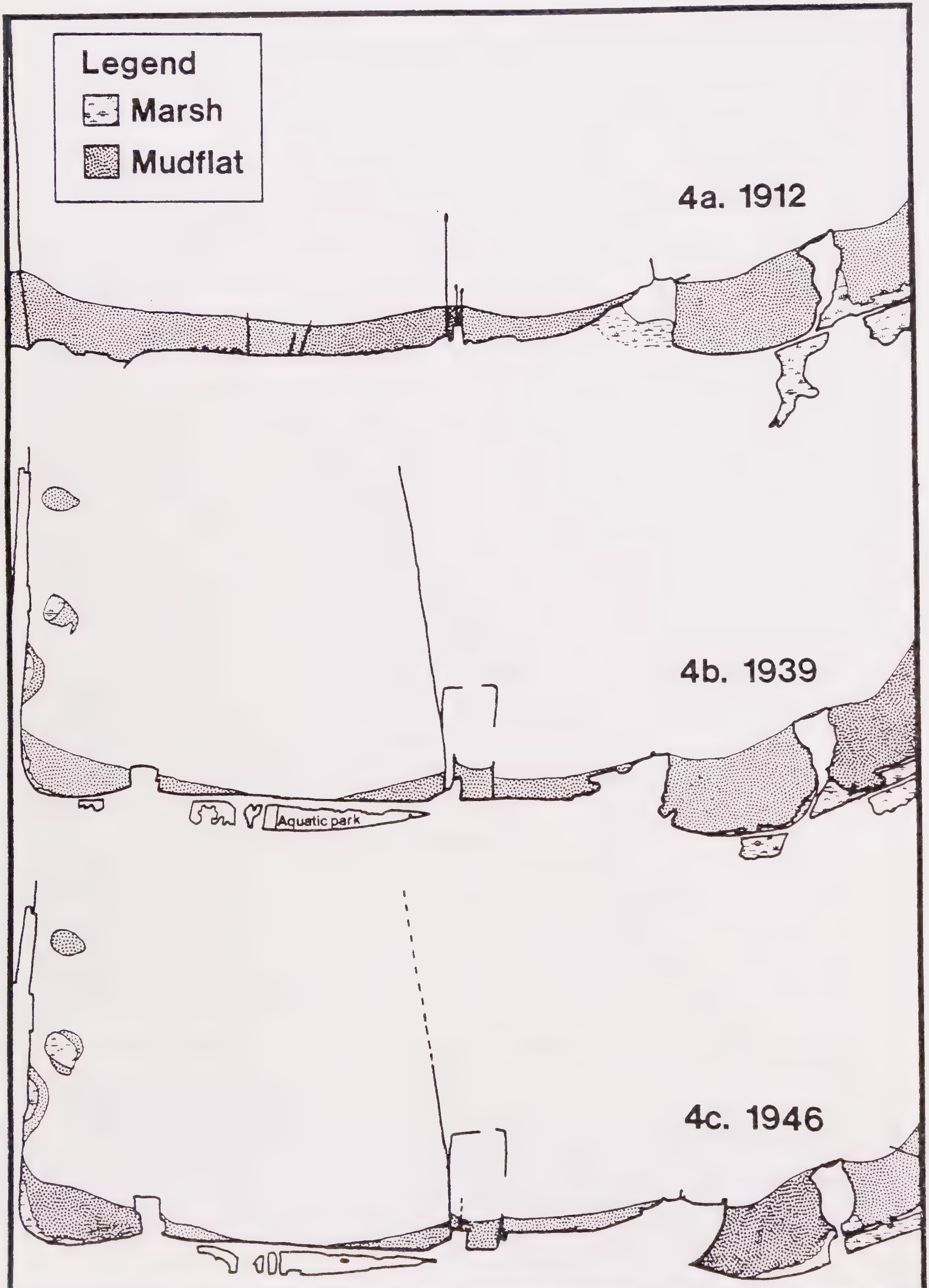
Examination of charts, maps and photographs shows that the shoreline has changed extensively since man's first major construction of piers in the area. The original shoreline was a fairly smooth sweeping curve south from Point Fleming, with the exception of minor creek deltas (FIGURE 1). FIGURE 4a shows some of the first

introductions: the Berkeley piers and piers on the site of the present Bay Bridge approach. More precise dates of landfilling are shown in FIGURE 5. The following is a description by region of the changes that have occurred, including marsh growth and shoaling.

A. The Emeryville Crescent and Marina. The first major construction in this area was a railroad pier, built in the early 1900's along the south edge of the study area. Some filling took place along the shore here at this time. There was a good deal more fill by 1931; another pier had been added just north of the old pier, and the area between them was filled (FIGURE 4b). No marsh was present at this time. The fill for the Emeryville Marina started in the mid-thirties and was fairly continuous until its completion around 1974 (nautical chart #19, 1974). The water between these two fills had begun to shallow by the 1930's. By the end of that decade two shoals or islands had appeared along the Bay Bridge approach. Marsh can be seen on one of these islands and along the Bay Bridge approach in the 1946 set of photographs, and the marsh has continued to grow since then.

Shallowing of the water has occurred to such a great extent that much of the area is presently exposed at very low tides. Most of this area is mudflat (FIGURE 4e), whereas in the early 1900's mudflats extended barely beyond the present shoreline (FIGURE 1, 4a). Nautical charts indicate that waters here have shallowed by 3 to 7 feet in the past 70 years (#2, 1912; #25, 1981), becoming half or less of their original depth. Additional fill has been added to the Crescent on top of new marsh. Fill has been added to the north shore of the Bay Bridge approach for construction of the toll plaza, and for radio towers, a road to the Duck Club (on the eastern most of the two islands) and an exit ramp for the Oakland Army Base.

B. Berkeley Embayment and the Ashby Shoal. North of the Emeryville Marina is the stretch of waters along which the Berkeley Beach has been proposed (see papers by Don Bachman, Peter Gee and Linda Goad). The site of the beach would be from the present Ashby exit ramp to the Brickyard, along Frontage Road. The present beach is almost completely covered at high tide. The proposed beach would have more sand and would be about three times longer. This part of the East Bay shore was filled in the early 1930's for a highway. The fill cut off water which is now Aquatic Park (FIGURE 4b). In the early 1950's more fill was placed along this stretch for Highway 80 and the present Frontage Road (Bill Russell, pers. comm., 1982). The Ashby "Bump" was placed there in the 1950's for the Ashby exit, and the


Legend
Marsh
Mudflat
4a. 1912
4b. 1939
Aquatic park
4c. 1946

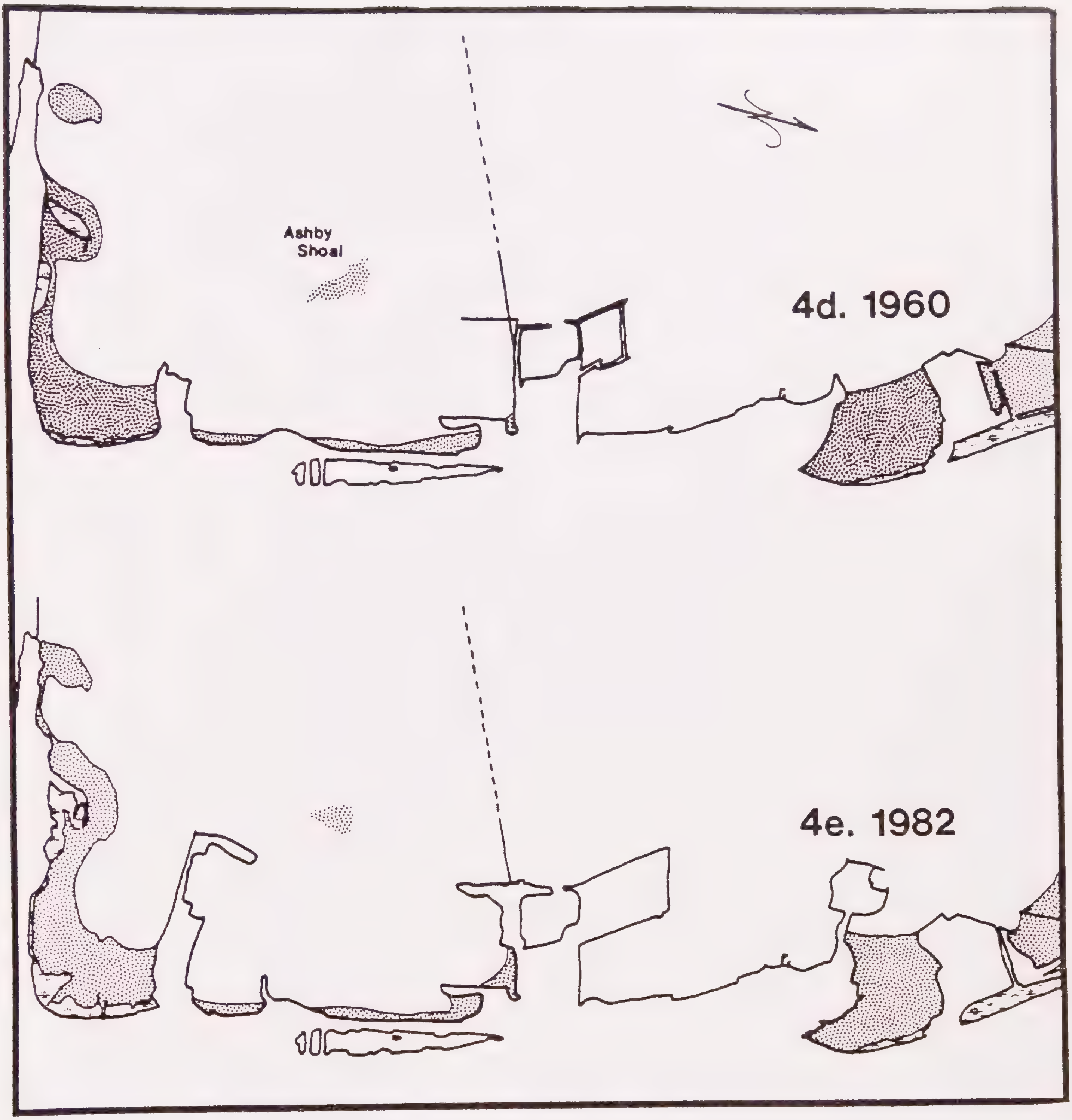


FIGURE 4. Progressive changes to the shoreline, as seen on aerial photographs. Mudflat area was estimated from mean lower low water on nautical charts. FIGURE 4a was determined from nautical charts; the rest from aerial photographs.

Source: Aerial photographs #13-34, 77-90; nautical charts #2, 6, 9, 11, 25.

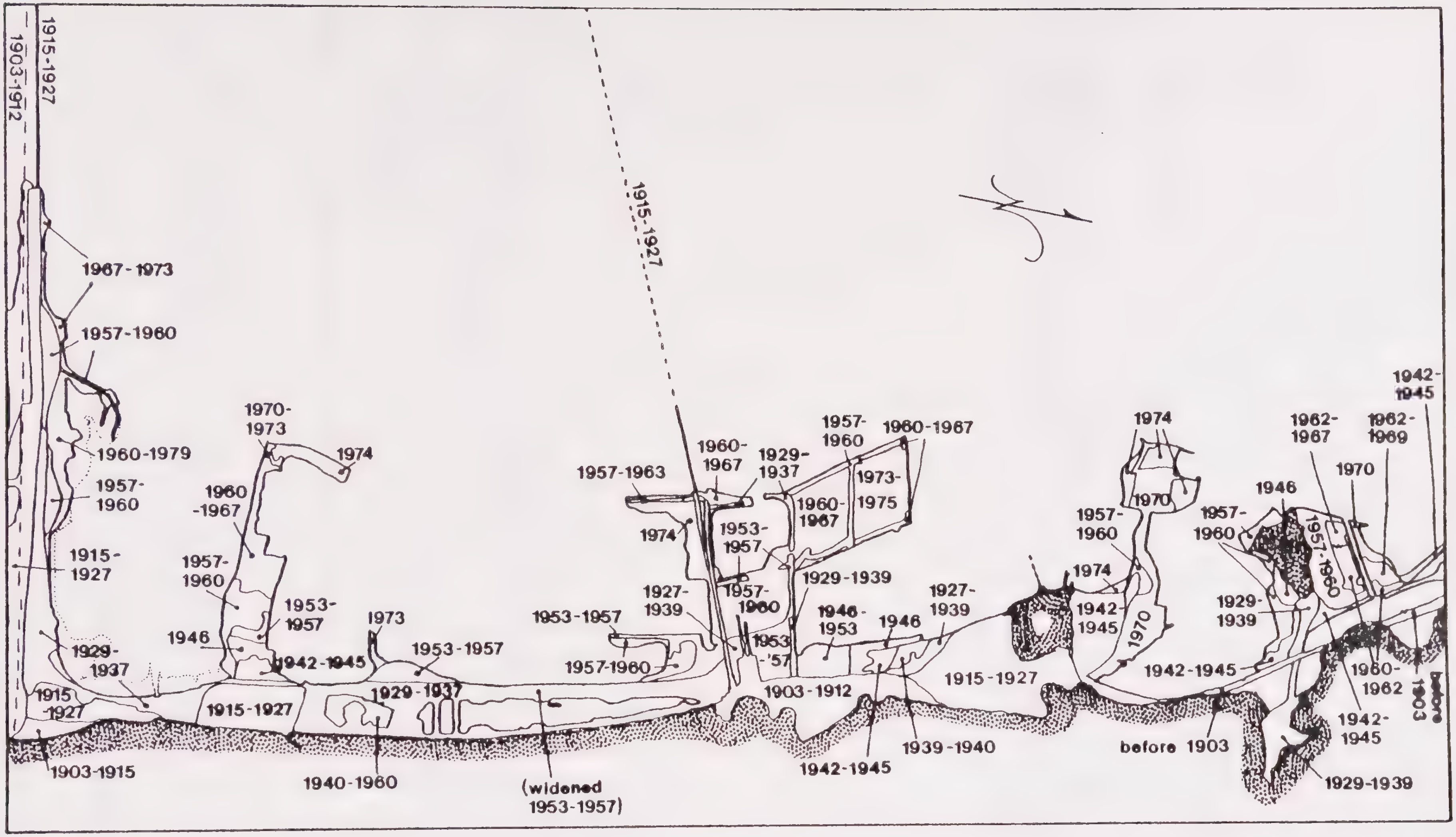


FIGURE 5. Dates of Landfill. Fill occurred between dates listed, not necessarily continuously.

Source: Aerial photographs #1-93; nautical charts #1-25.

Ashby spit went in about 1974. Fill for the Brickyard was completed by 1970 (see paper by Debbie Robinson).

The first appearance of the Ashby Shoal on aerial photographs studied was in 1960 (FIGURE 4d). It may have been formed solely during highway construction. Mud was pumped from the highway site out into the bay and sand pumped from the bay back to the site, since fine bay mud is not ideal for building on (see paper by Mary Dresser). It is possible that the Ashby Shoal is a result of the mud pumped out there and a hole, to the southwest of the shoal, about 25 feet deep (nautical chart #25, 1981) is left from the removal of sand (Bill Russell, pers. comm., 1982). That there was sand in this region indicates that circulation patterns had allowed sand to accumulate, instead of bay mud, prior to highway construction. It is possible that a shoal had also begun to form naturally. The shoal and hole were not present in 1939 (FIGURE 4b); data compiled from photographs shows a slight bar about 1000 feet farther west than the present shoal site (see Appendix B). This bar was smaller and deeper than the shoal. That the bar is the initial appearance of the shoal is possible, but I do not think it likely, due to the differences in location. The bar may well have been the source of sand used in highway construction. Since no waves are shown in 1946 photographs, depths could not be calculated, but no change in tone is present on photographs where the shoal now is. Photos from 1960, in contrast, show marked tonal changes in the region of the shoal (FIGURE 4d). Nautical charts do not record the shoal until after 1968 (nautical chart #14, 1969).

C. Berkeley Marina. The earliest piers were constructed at this site around the turn of the century. The longest one in 1912 was no longer in use by 1927, and fill since then has covered it over. The old pilings run under University Avenue, and have caused some problems of uneven settling. The area known as the Murphy-Santa Fe land, The Meadow, or The Kite Field, was filled between 1953 and 1967, after which the north arm of the marina landfill was started. This area is still being filled and is nearly completed.

D. Point Fleming and the Albany Landfill. Point Fleming is original bedrock, a peninsula connected to the mainland only by marsh in the 1850's. By 1912 some fill had occurred in the form of a road to the point, and two piers had been built off the point. These piers are not the same two which are there at present. One of the original two has since been covered over by landfill. All that is left of the other is a few pilings, south of the present piers which were probably built in the 1930's. The marsh between Point Fleming and the mainland was filled in completely by 1927,

and landfill began to the north and south at that time. The Albany landfill has gone in gradually and fairly continuously up until the present. It is nearly finished, except for a proposed marina to the south. There was originally a beach along the southwestern shore of Point Fleming. The sand from this beach was gradually all hauled away for building foundations. The beach has not reappeared, although two other beaches have appeared just north of this site near the two new piers.

Response to Fill

Marsh Expansion: The appearance of the extensive marsh in the Emeryville Crescent is a major natural response to past man-made fill. FIGURE 6 shows the expansion of this marsh from 1931 to the present as shown on aerial photographs. Some inaccuracy is present due to tide levels (high tides cover some vegetation), in addition to inaccuracies discussed under Sources and Methods of Examining Data. Area given in FIGURE 6 is actually that of total vegetation, which includes trees, bushes and introduced plants, such as iceplant on higher ground (inland border of marsh). Some regions which developed into marsh were subsequently covered over by land fill, which is also included in the area on FIGURE 6. The general trend, if the growth of area is approximately linear (solid line, FIGURE 6), is for marsh area to increase at a rate of about 2 acres (7000 m^2) per year. The total area of the Emeryville Crescent region (Bay Bridge approach to Emeryville Marina) is approximately 650 acres (2.7 million m^2), and at present 14% is covered with marsh. The growth of marsh appears to be exponential (broken line, FIGURE 6). If this is the case, then the marsh is expanding at a rate greater than two acres per year, and this rate will continue to increase until some limiting factor, such as deep water, currents, or strong waves, is encountered.

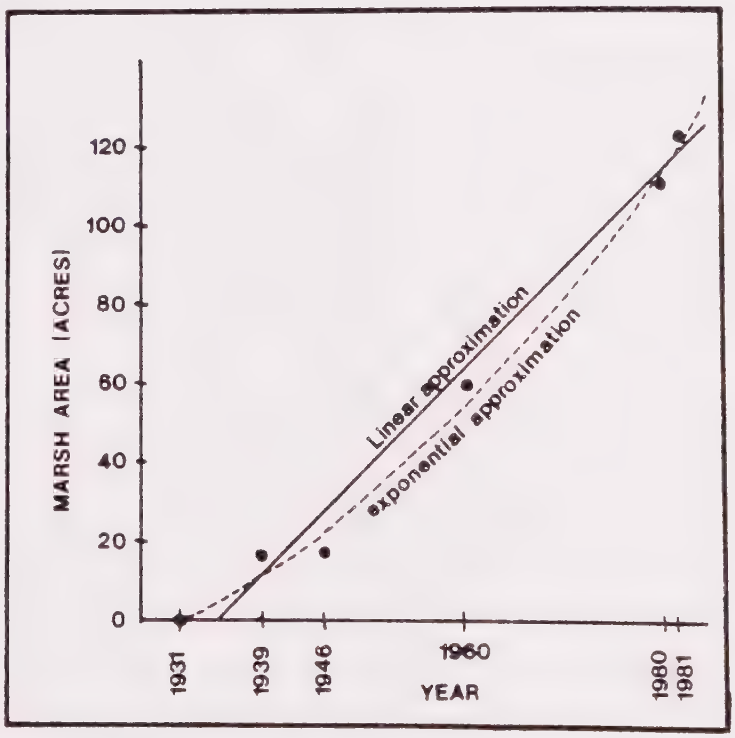


FIGURE 6. Growth of Marsh in the Emeryville Crescent.

Source: Aerial photographs #1-12, 16-18, 32, 89, 92.

Beaches: FIGURE 7 records beaches as seen on aerial photographs. It should be noted that these "beaches" are not necessarily desirable picnic spots: they are sites where silt, sand, pebbles, rocks and debris have collected due to wave and current action. Such sites, while not necessarily desirable at present, might hold sand placed there. They are, therefore, prospective sites for man-made beaches. Other studies must be done, of course: if materials at the sites have a high turnover rate or these materials are not suitable for a beach, providing a constant outside supply of sand may be too costly. If a large amount of debris is constantly washed up on the shore a beach may not be practical there either.

Almost all waves seen on aerial photographs follow a gentle curve along their length which matches the original curve of the shoreline, until they come close enough to shore to encounter the effects of new fill. In these areas, some refraction occurs. These waves indicate that prevailing winds come from the west, if the waves seen on aerial photographs can be assumed to be representative of average waves. Study of the direction of waves in relation to beaches present along the East Bay shoreline reveals that beaches are or have been present only where waves are consistently parallel to the beach. Waves were parallel to the old Berkeley Beach site (FIGURE 7, A) in 1939. In 1977 and 1979 photos (#38, 67) the waves are at about a 30° angle, and in 1978 (#52) the waves are virtually perpendicular to this shore. This change in wave direction may be due to refraction around the Berkeley Sanitary Landfill.

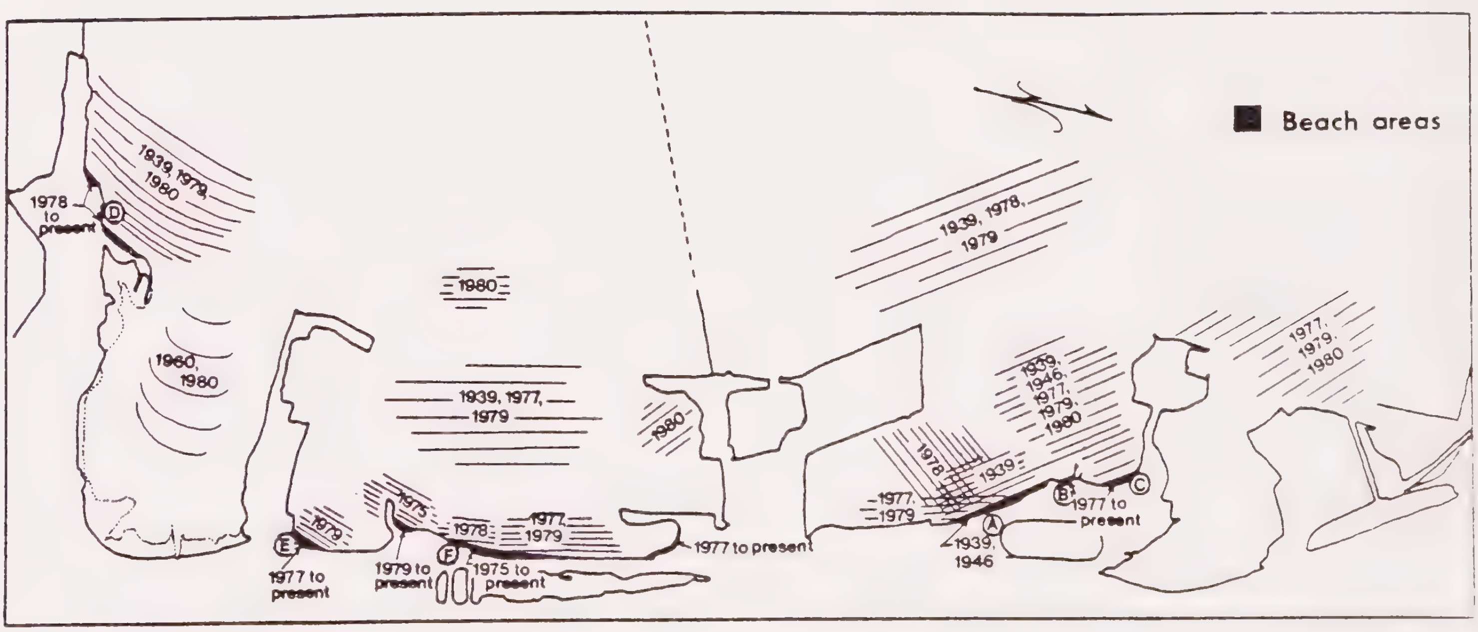


FIGURE 7. Wave Direction and Beaches, as Seen on Aerial Photographs. Beach Size Is Exaggerated for Clarity.

Source: Aerial photographs #13-30, 37-47, 51, 63, 66, 77-93.

The original beach has not returned for two possible reasons: (1) there was not a supply of sand to replace it, or (2) the wave action has prevented replacement. Two small beaches have developed just north of the original site (B, C, FIGURE 7) where the wave action has not been blocked. This wave action has been within 10° of parallel to the shore, as seen in 1977, 1979 and 1980 photographs (#43, 60, 66, 82, 83). Beaches were not present here prior to 1945 because landfill had not yet created this shoreline (see FIGURE 5). Beaches have also developed along the west shore of the Duck Club road (D, FIGURE 7) and at Carlos Murphy's (E, FIGURE 7), where waves are parallel to the shore in 1979 photographs. The beach which has developed on the proposed Berkeley Beach site (F, FIGURE 7) has had waves within 10° of parallel for recent years (1977-81, earlier data are not available).

Summary

Emeryville Crescent waters have shallowed considerably in the past seventy years. The material probably placed there during highway construction has not been removed by wave action or currents, and considerable additional shallowing has taken place since the construction. A protecting headland (the Emeryville Marina) has been present for the past fifteen years. Combined with the Duck Club peninsula, waves are mostly blocked; only a small protion of the wave energy enters these waters and these waves are highly diffracted (see FIGURE 7). The Bay Bridge approach has had solid fill for about fifty years, and has acted as a groin, trapping material.

The Berkeley Embayment has shallowed by only about one foot in seventy years, with the exception of the Ashby Shoal. The Embayment, too, has a projecting fill to the north, the Berkeley Marina, and the Emeryville Marina to the south, but wave action is from the west, and the opening between the two marinas is large enough for the predominantly north-south currents to enter. The Shoal may protect the area from wave action to some extent, but it does not provide as much protection as is provided for the Emeryville Crescent, since it is often submerged by several feet (at high tide).

The Albany Mudflat has not changed to any great extent, and this may be due to the fact that Point Fleming and Point Isabel, which flank it, are natural points: since they have been present for a much longer amount of time than fills discussed above, most of the effects (shallowing; development of mudflat) occurred well before the earliest dates of photographs used in this study. The Albany Landfill may in part be the cause of slight expansion of the mudflat, since it may block waves which would otherwise enter the mudflat.

The greatest change that has occurred along the shoreline is the introduction of large expanses of landfill. This in turn has aided siltation of protected waters. Another development has been growth of large expanses of marsh over the past fifty years, especially in the Emeryville Crescent, which has drawn a great variety of wildlife into this urbanized area.

Appendix A. Source List

Aerial Photographs

No.	Agency Code	Color	Angle	Agency	Date
1	C1600-11	B & W	normal	Teledyne	5/27/31
2	C1600-12	B & W	normal	Teledyne	5/27/31
3	C1600-13	B & W	normal	Teledyne	5/27/31
4	C1600-14	B & W	normal	Teledyne	5/27/31
5	C1600-15	B & W	normal	Teledyne	5/27/31
6	C1600-16	B & W	normal	Teledyne	5/27/31
7	C1600-22	B & W	normal	Teledyne	5/27/31
8	C1600-23	B & W	normal	Teledyne	5/27/31
9	C1600-24	B & W	normal	Teledyne	5/27/31
10	C1600-25	B & W	normal	Teledyne	5/27/31
11	C1600-26	B & W	normal	Teledyne	5/27/31
12	C1600-27	B & W	normal	Teledyne	5/27/31
13	BUT-BUU-289-96	B & W	normal	USAAA	8/2/39
14	BUT-BUU-289-97	B & W	normal	USAAA	8/2/39
15	BUT-BUU-289-98	B & W	normal	USAAA	8/2/39
16	BUT-290-3	B & W	normal	USAAA	8/4/39
17	BUT-290-4	B & W	normal	USAAA	8/4/39
18	BUT-290-5	B & W	normal	USAAA	8/4/39
19	BUT-290-6	B & W	normal	USAAA	8/4/39
20	BUT-290-7	B & W	normal	USAAA	8/4/39
21	BUT-290-8	B & W	normal	USAAA	8/4/39
22	BUT-290-9	B & W	normal	USAAA	8/4/39
23	5-9	B & W	normal	USGS	9/6/46
24	5-10	B & W	normal	USGS	9/6/46
25	5-11	B & W	normal	USGS	9/6/46
26	5-12	B & W	normal	USGS	9/6/46
27	6-11	B & W	normal	USGS	10/28/46
28	6-12	B & W	normal	USGS	10/28/46
29	6-42	B & W	normal	USGS	10/28/46
30	6-43	B & W	normal	USGS	10/28/46
31	AF59-45-717	B & W	normal	USAF	4/3/60
32	AF59-45-718	B & W	normal	USAF	4/3/60
33	AF59-45-742	B & W	normal	USAF	4/3/60
34	AF59-45-743	B & W	normal	USAF	4/3/60
35	8674-7 (CC)	B & W	oblique	CalTrans	2/28/62
36	Not available	B & W	normal	USGS	April, '70
37	Not available	B & W	normal	Not avail.	Sept, '75
38	C6282-3	B & W	oblique	CalTrans	9/20/77
39	C6282-5	B & W	oblique	CalTrans	9/20/77

Aerial Photographs, continued

No.	Agency Code	Color	Angle	Agency	Date
40	SFB-7-3	B & W	normal	COE	12/1/77
41	SFB-7-4	B & W	normal	COE	12/1/77
42	SFB-7-5	B & W	normal	COE	12/1/77
43	SFB-7-6	B & W	normal	COE	12/1/77
44	SFB-7-7	B & W	normal	COE	12/1/77
45	SFB-7-2	B & W	normal	COE	12/14/78
46	SFB-7-6	B & W	normal	COE	12/14/78
47	SFB-7-7	B & W	normal	COE	12/14/78
48	04-Ala-580 8-21	B & W	normal	CalTrans	12/3/78
49	04-Ala-580 8-22	B & W	normal	CalTrans	12/3/78
50	04-Ala-580 8-23	B & W	normal	CalTrans	12/3/78
51	04-Ala-580 8-24	B & W	normal	CalTrans	12/3/78
52	40-CC-80 8-25	B & W	normal	CalTrans	12/7/78
53	04-Ala-580 8-26	B & W	normal	CalTrans	12/3/78
54	04-CC-17.80 8-27	B & W	normal	CalTrans	12/3/78
55	04-CC-17.80 8-28	B & W	normal	CalTrans	12/3/78
56	SFB-7-2	B & W	normal	COE	4/13/79
57	SFB-7-3	B & W	normal	COE	4/13/79
58	SFB-7-4	B & W	normal	COE	4/13/79
59	SFB-7-5	B & W	normal	COE	4/13/79
60	SFB-7-6	B & W	normal	COE	4/13/79
61	SFB-7-7	B & W	normal	COE	4/13/79
62	C7032-20	true color	oblique	CalTrans	9/27/79
63	C7032-21	true color	oblique	CalTrans	9/27/79
64	C7063-1	true color	oblique	CalTrans	9/27/79
65	C7063-2	true color	oblique	CalTrans	9/27/79
66	C7063-3	true color	oblique	CalTrans	9/27/79
67	C7063-4	true color	oblique	CalTrans	9/27/79
68	C7063-5	true color	oblique	CalTrans	9/27/79
69	C7063-6	true color	oblique	CalTrans	9/27/79
70	C7063-7	true color	oblique	CalTrans	9/27/79
71	C7063-8	true color	oblique	CalTrans	9/27/79
72	C7063-9	true color	oblique	CalTrans	9/27/79
73	C7063-11	true color	oblique	CalTrans	9/27/79
74	SFB-7-2	B & W	normal	COE	4/8/80
75	SFB-7-3	B & W	normal	COE	4/8/80
76	SFB-7-4	B & W	normal	COE	4/8/80
77	SFB-32-5	color IR	normal	COE	5/17/80
78	SFB-32-6	color IR	normal	COE	5/17/80
79	SFB-32-7	color IR	normal	COE	5/17/80
80	SFB-32-8	color IR	normal	COE	5/17/80
81	SFB-32-9	color IR	normal	COE	5/17/80
82	SFB-32-10	color IR	normal	COE	5/17/80
83	SFB-32-11	color IR	normal	COE	5/17/80
84	SFB-32-12	color IR	normal	COE	5/17/80
85	SFB-32-13	color IR	normal	COE	5/17/80

Aerial Photographs, continued

No.	Agency Code	Color	Angle	Agency	Date
86	SFB-38-11	color IR	normal	COE	6/17/80
87	SFB-38-12	color IR	normal	COE	6/17/80
88	SFB-38-13	color IR	normal	COE	6/17/80
89	SFB-38-14	color IR	normal	COE	6/17/80
90	SFB-38-15	color IR	normal	COE	6/17/80
91	SFB-10-1	B & W	normal	COE	9/31/81
92	SFB-10-2	B & W	normal	COE	9/31/81
93	SFB-10-3	B & W	normal	COE	9/31/81

Nautical Charts

No.	Code	Agency	Date of publ.	Last revision
1	5532	USCGS	1903	
2	5532	USCGS	1912	
3	5532	USCGS	1915	
4	5532	USCGS	1927	
5	5532	USCGS	1927	1928
6	5532	USCGS	1937	1940
7	5532	USCGS	1941	1942
8	5532	USCGS	1943	1945
9	5532	USCGS	1947	1950
10	5532	USCGS	1947	1952
11	5532	USCGS	1957	
12	5532	USCGS	1967	
13	5532	USCGS	1968	
14	5532	USCGS	1969	
15	5532	USCGS	1970	
16	5532	NOS	1971	
17	5532	NOS	1972	
18	5532	NOS	1973	
19	5532	NOS	1974	
20	18649	NOS	1975	
21	18649	NOS	1977	
22	18649	NOS	1978	
23	18649	NOS	1979	
24	18649	NOS	1980	
25	18649	NOS	1981	

Abbreviations:

USAAA US Agricultural Adjustment Administration
USGS US Geological Survey
USAF US Air Force
CalTrans California Department of Transportation
COE US Army Corps of Engineers
USCGS US Coast and Geodetic Survey
NOS National Oceanic Survey

APPENDIX B

DEPTH DETERMINATION FROM AERIAL PHOTOGRAPHS

Wavelengths measured on aerial photographs may be converted to water depths according to the following formula:

$$T^2 = \frac{2\pi\lambda}{g} \cot h \frac{2\pi d}{\lambda} \quad \text{(Lundahl, 1948)}$$

where g is the acceleration of gravity, 32.2 ft/sec^2, T is the period of the wave, d is the depth of the water, and λ is the wavelength, measured crest to crest. One depth d_o and corresponding wavelength λ_o must be known in order to calculate the period T, which is constant for a given set of waves. With T and other wavelengths measured, other depths can be calculated using the same formula.

It is necessary to take tide levels into account, since they can change depths by as much as six feet. To do this, the time and day the photograph was taken is determined, and tide levels are obtained from tables. In some cases, especially for older photographs, the time is not available. For these photographs a measurement is taken of the angle of a shadow cast by a tall object across level ground, with reference to some prominent fixed object such as a street. The angle can then be used to determine the time of day according to sun charts (Libby-Owens-Ford, 1975), which unfortunately are not generally available for latitude 37.8°N (Berkeley). They are available for 36°N and 40°N, but the difference introduces an inaccuracy of up to an hour, which is undesirable when determining tide levels. A more accurate method of finding the time is by using the following formula:

$$\left(\cos^2 L \cos^2\delta - \frac{\cos^2\delta}{\sin^2\phi}\right)\cos^2\omega + \tfrac{1}{2}\sin 2\delta \sin 2L \cos\omega$$

$$= 1 - \sin^2 L \sin^2\delta - \frac{\cos^2\delta}{\sin^2\phi} \quad *$$

where L is the latitude (37.8°), ϕ is the angle of the sun (from true south, positive to the east, does not include vertical angle), δ is the declination, determined from the day of the year ($\delta = 23.45\sin[(284 + n)360/365]$, n is the day: Jan 1st = 1, Feb 1st = 32, etc.), and ω is the hour angle. While this equation looks quite difficult, all values are known except ω. Since the equation is a simple quadratic of $\cos^2\omega$, $\cos^2\omega$ can be solved for, ω can be solved for, and the hours before or after solar noon (= PST noon plus 9 minutes in Berkeley) found by dividing ω by 15. The shadow will tell whether these hours should be added to or subtracted from solar noon: if the shadow lies west of true north it is before noon, and the value should be subtracted.

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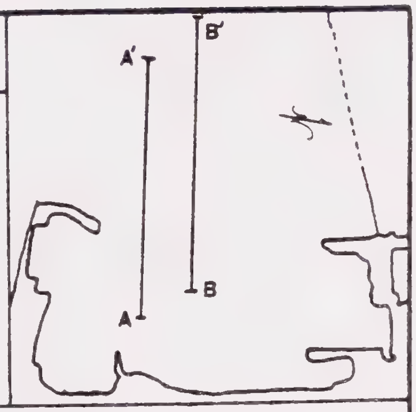
*Derived from $\cos z = \cos L \cos\omega \cos\delta + \sin L \sin\delta$, and $\sin\phi = \cos\delta \sin\omega / \sin z$ (Merriam, 1980, pers. comm.).

Depths in the Berkeley Embayment, 1939

Date: 8/4/39
Time: 4:40pm PST
Tide: +5.5 ft.*
λ_0 = 54.4 ft.
d_0 = 15.5 ft.**
T = 11.2 sec. (eq. 1)
d = wavelength in ft.
d = depth in feet
L = distance from Frontage Rd., along AA' or BB' in hundreds of feet.

	λ	d	L		λ	d	L
a	54.4	15.5	103	k	54.4	15.5	109
b	42.5	6.5	90	l	51.0	11.5	99
c	49.4	10	87	m	43.9	7	92
d	47.6	9	78	n	51.0	11.5	90
e	45.3	7.5	70	p	49.6	10	73
f	45.3	7.5	65	q	42.5	6.5	65
g	47.4	9	56	r	45.3	7.5	54
h	45.3	7.5	52	s	47.6	9	43
i	42.5	6.5	39	t	46.2	8	37
j	38.5	5	33				



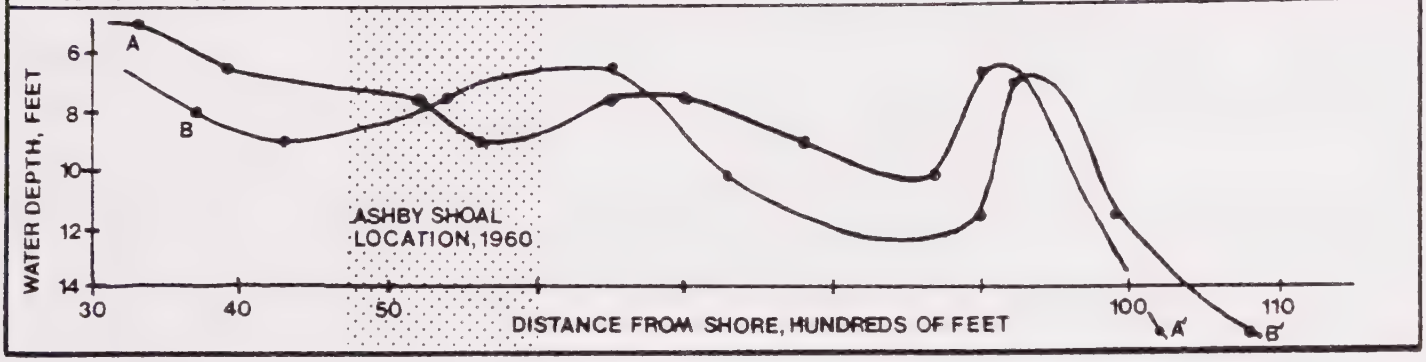


TABLE 1. Wavelength to depth conversion, Berkeley Embayment, 1939. Points a through j are on data line AA' (see insert); points k through t are on BB'. Data plotted above indicate a bar or shoal about 1000 feet west of the present Ashby Shoal, and a second bar well beyond this. The first of these is referred to in the text. Source: Aerial photograph #19.
*S. F. Chronical, 8/4/39; **Nautical chart #6.

REFERENCES CITED

Bascom, W., 1964. Waves and Beaches: New York, Doubleday Anchor, 267 pp.

Friedman, G.M., and J.E. Sanders, 1978. Principles of Sedimentology: New York, John Wiley and Sons, 792 pp.

Libby-Owens-Ford Company, 1975. Sun Angle Calculator: Ohio, 25 pp., plus 4 charts.

Lundahl, A.C., 1948. Underwater Depth Determination by Aerial Photography, pp. 61-69 in El-Ashry, M.T., ed., 1977. Air Photography and Coastal Problems: Strousburg, PA, Dowden, Hutchinson and Ross, 425 pp.

Merriam, M.F., Professor of Engineering, UC Berkeley, pers. comm., 1980.

Nichols, D.R., and N.A. Wright, 1971. Preliminary Map of Historic Margins of Marshland, San Francisco Bay, California: U.S. Geological Survey, Open File Report (Basic Data Contribution 9), 10 pp. plus map.

Russell, Bill, Senior Transportation Engineer, Retired, California Department of Transportation, pers. comm., 1982.

San Francisco Chronicle, Aug. 4, 1939. Sun, Moon and Tide Chart, p. 23.

Chapter 3

LAND STABILITY ALONG THE EAST BAY SHORELINE

Mary Dresser

The East Bay shoreline area under study is not the original bay shoreline; rather it is composed of landfill which has been placed since the 1920's. In order to be thorough in the planning process for the area, one must consider the type of land on which future developments of any kind may occur. When structures are built on the filled areas covering the perimeter of the bay, it is important to know what the foundation soils under the fill are, what is used for fill material, and the physical properties of these two components under various conditions.

Foundation Soils

Foundation soils are the substrate upon which fills are placed. The success or failure of a fill is often due to the type of foundation soil on which it is placed. Three types of substrate occur on the bay bottom (excluding the underlying bedrock): older bay mud, sand deposits, and younger bay mud.

Older bay mud is a silty clay, with varying amounts of sand and gravel, and is of less than 40% weight water. It blankets and fills channels in the bedrock. It is in an overconsolidated state, which means that it is denser than would be expected just from the weight of the sediments which overlie it. It is overlain by either sand or younger bay mud (Goldman, 1969). It would be a good foundation for fill: however, it is generally overlain by weaker foundation soils.

Sand deposits are found in a number of lenses which occur between the older and younger bay mud units. There are some areas where sand lenses occur within the younger bay mud as thin layers, or as fingers which interdigitate with the bay mud. The sand is a preferable foundation soil to younger bay mud, although under certain seismic conditions it can become liquified and lose its ability to bear a load.

Younger bay mud (bay mud for brevity) is the foundation soil on which most fill material is placed. The bay mud is of estuarine origin and is a soft, plastic silty clay with particles ranging from clay size (less than 2 microns) to very fine sand (less than 100 microns). It is much more moist than older bay mud with more than 50% of its weight in water. Included in the mud are various

organic substances such as shells, vegetable matter, and peat. There are also lenses and stringers of sand and gravel. The buildup of the bay mud occurred over a long period of time. When the oceans rose as glaciers melted, the previously exposed valleys and ravines of the bay were inundated, and the bay mud was deposited. Because the topography of the underlying bay bottom is irregular, the thickness of the bay mud varies greatly (Lee and Praszker, 1969).

The bay mud is in an unconsolidated, semi-fluid, jelly-like state. There are water- or air-filled voids in the bay mud which take up about twice the volume of the solid particles. Bay mud is highly impermeable, that is, it is very difficult to squeeze the water out of the voids. Because of this, bay mud is weak and incapable of supporting appreciable loads. In order to decrease the volume in the voids and hence consolidate the mud, it is necessary to force the water and air out of them. An applied external pressure will help the process and accelerate it.

Fill Materials

Fill generally relates to material which can be placed on firm or semi-liquid ground with a resulting increase in the surface elevation. Various materials are used for fill. Sand is an important source of hydraulic fill in the bay. Other sources of fill material include dredged bay mud, garbage mixed with sand, and imported and compacted fill from excavations and grading of land in the hills. Commercial quarries produce stone for use as rip-rap, but this material cannot be used as fill on bay mud as it simply sinks into the mud without appreciably raising the ground level (Goldman, 1969).

Reaction of the Bay Mud to Imposed Loads

Bay mud is a semi-viscous "jelly" which can easily change in geometrical configuration. When fill is placed on bay mud, the mud will behave more like a plastic than a solid, and will try to move rather than compact under the load. The capacity of the bay mud to support an external load such as fill material is not measured so much by the force of the load as by the deformation that the load may cause in the mud (Lee and Praszker, 1969).

Bay mud will tend to flow laterally when fill is placed on it. If it were possible to confine the mud laterally, then the only effect of placing the load on the mud would be to compact the mud and force the water and air out of the voids. In that case the mud could support an almost infinite load. In reality the mud isn't confined and can therefore move laterally if an appreciable load is placed on it. When fill material is placed on mud, the force it exerts on the mud must

be kept low (no more than 300 lbs/ft^2) to keep the lateral deformation to a minimum. It would be ideal if the load could cover the entire fill area at once, so as to spread the load out equally over a large area and thereby decrease the load which each individual unit of bay mud would have to support. In actual practice the fill material is placed by end-dumping on a limited area. The material is spread stage-by-stage. Areas toward the edge of the fill which haven't yet been loaded are free to react plastically due to the load on the adjacent areas (Lee and Praszker, 1969).

If fill material is placed incorrectly, these areas bulge or produce mud waves, while the filled areas tend to sink. When mud waves form, the mud is said to be in a state of "plastic flow." Mud waves should be avoided in a fill as they will cause unequal, or differential, settlement of the fill over time. To prevent the occurrence of mud waves, the ideal method of placing fill material is by means of a hydraulic dredge, whereby the dredger pours fluid and fill material such as sand or mud over large areas and the sediment builds up slowly and evenly (Lee and Praszker, 1969).

Fill which is placed in this manner acts as a "blanket." A large fill blanket normally constitutes an area of infinite dimensions, so that each elemental area of the mud under the center of the blanket is protected by confining pressures from its neighboring mud units. Conditions change rapidly when approaching the edge of the fill blanket. At the center of the fill area, the mud is confined and so can only move downward due to the imposed load of the fill material. At the edges of the fill, however, the mud is no longer confined by neighboring units or an imposed load, and is free to move upwardly and laterally. The maintenance of flat slopes at the boundaries of the fill may help control the tendency of the mud to flow plastically away from the imposed load.

Plastic flow of mud at the edge of a fill is one type of boundary condition. Fill may also be placed on mud which rests on an inclined plane. In this case, gravity will pull the loaded fill and mud slowly down the incline. Two typical boundary conditions may occur; the boundary closest to shore may show cracks of the fill and the offshore boundary may show heaving of the mud beyond the fill.

Placing the fill hydraulically at a slow rate may prevent problems such as mud waves and lateral movement of the mud. The rate of filling shouldn't exceed 3 ft/yr. The height of the final fill should also be limited.

Settlement of Fill

Once fill material has been placed on the mud, it and the underlying mud will settle for various reasons including: time, settlement of the fill material itself, plastic flow of the mud under the fill load, lateral movement of the mud resting upon an inclined surface, and seismic activity (Lee and Praszker, 1969).

Fill material will settle to a certain degree over time, regardless of the quality and degree of compaction of the fill material (FIGURE 1). The amount of settlement over time is a function of the compressibility of the mud, its depth (thickness), and the density and height of the overlying fill material. In ideal situations the fill will settle uniformly over time, but in practice the mud thickness, fill thickness, and fill density are not uniform throughout the fill area so that differential settlement occurs.

Uniform settlement of newer fills shouldn't be expected on bay mud. Even on older filled areas, some differential settlement will occur when a load is imposed on it. The amount of differential settlement on older fills can be determined by field observations, and design features should be incorporated into structures which are to be placed on the older fills.

The final settlement of 10 feet of fill over 40 feet of bay mud is 4 feet (FIGURE 1), and 48% of this settlement will take place in the first five years (FIGURE 2). Thus, from FIGURE 2 it can be seen that the most critical settlement of fills on bay mud less than 40 feet thick takes place in the first five years. On these older fills (i.e., over five years old, as in the area being studied), it can be assumed that future settlement will follow the observed settlement, will be slow and not in excess of six inches. The differential settlement will probably be only about 3 inches in 20 years (Lee and Praszker, 1969).

A process known as surcharging is sometimes used to alleviate some of the problems of settlement. A larger amount of fill than is ultimately intended is placed on the site. After enough time has passed for the mud to compress, the excess fill is removed. Further settlement of the mud is largely reduced or eliminated.

Seismic Hazards

There are several serious problems to contend with in the event of an earthquake. Earthquakes are displacements of the earth along faults. Neither horizontal rupture nor vertical faulting should be a problem in the area of study, as no known faults underlie the area.

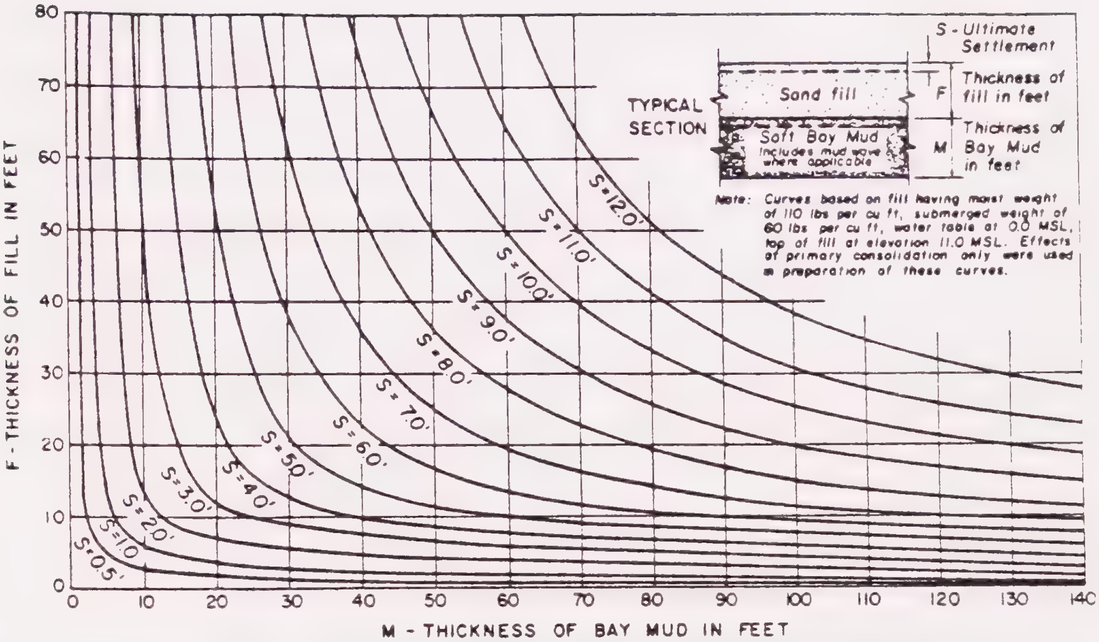


FIGURE 1. Settlement of Fills as a Function of Thickness of the Fill and Thickness of the Underlying Bay Mud.

Source: Lee and Praszker

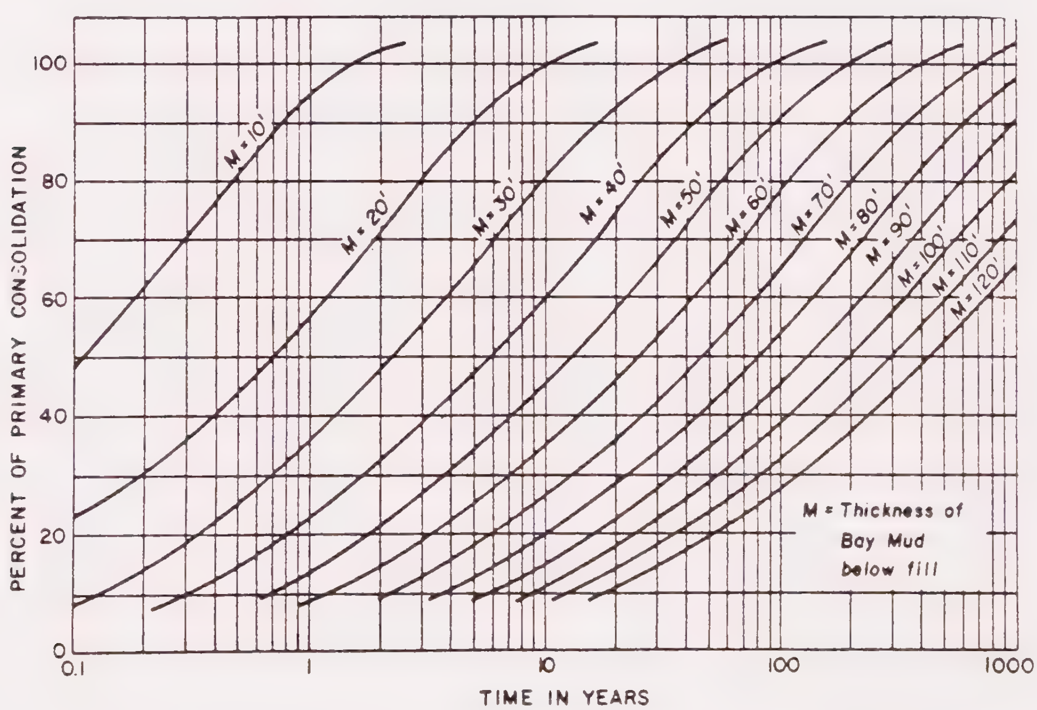


FIGURE 2. Percent Settlement of Fills over Time as Function of the Thickness of the Bay Mud

Source: Lee and Praszker

The most familiar aspect of earthquakes is ground shaking. There is a general decrease in the intensity of ground vibrations with distance from the epicenter of a quake. However, there are local variations in intensity due to soil conditions. Bay muds can magnify the effects of ground shaking by amplifying the intensity of shaking at certain frequencies. In some cases, the amplification of ground shaking is greater than the attenuation caused by distance from the epicenter (Borcherdt et al., 1975). For example, during the 1906 earthquake there were wide variations in the amount of damage done in different areas. Structures built on filled areas suffered greater damage than did those built on bedrock.

The effects of amplified ground shaking are expected to be least for those sites underlain by bedrock, intermediate for those underlain by older bay mud, and greatest for those underlain by fill and bay mud (Borcherdt et al., 1975). It is interesting to note that the areas for which the effects of amplified ground shaking are expected to be the greatest are also those areas that are the most susceptible to liquefaction.

Liquefaction is the transformation of a granular material from a solid state into a liquefied state. If saturated cohesionless soils are subjected to earthquake vibrations, the tendency to compact may be accompanied by an increase in the water pressure in the voids in the soil, which results in an upward flow of the water to the surface. The water emerges as mud spouts or sand boils (Seed, 1969). The potential of soil to liquefy is estimated from an analysis of the severity and duration of ground motion, the depth of the water table, and the depth of clay-free granular sediments (Youd et al., 1975). Virtually all of the bay mud and deposits underlying bay mud lie below the normal groundwater table and present a persistent potential for liquefaction (Youd et al., 1975).

There occur clay-free granular layers within the bay mud which have a high potential for liquefaction. If liquefaction occurs in a sloping soil mass, the entire mass will move laterally to the unsupported side. These flow slides can occur on ground with a low slope and can be instigated by relatively small earthquakes. The most common failures during liquefaction which occur on gentle to nearly horizontal slopes are lateral-spreading landslides. During these landslides, the soil will liquefy and flow, then resolidify, and reliquefy if the ground keeps shaking. The margins of lateral-spreading failures usually crack and settle differentially (Youd et al., 1975). Lateral spreading landslides would probably be the most pervasive type of ground failure associated with liquefaction on the edges of the bay. Much of the bay mud experienced lateral-spreading during the

1906 earthquake (Youd _et al_., 1975).

Soil which liquefies on level ground is known as "quick" soil. Quick soil often loses its bearing capacity with the result that structures, embankments or other loads sink into the liquefied ground. Buried tanks or other buoyant vessels may rise to the surface. Since most of the ground on the East Bay shoreline is gently sloped, lateral-spreading landslides will be a greater problem than quick soil, should the area liquefy during an earthquake. It is known that liquefaction occurs in clay-free granular layers; however, the actual locations of these layers isn't known sufficiently well to be able to plot them (Youd _et al_., 1975).

Many instances of bulkhead failure have occurred during earthquakes due to liquefaction of the backfill. The bulkheads are sheet pile or concrete walls which are placed in the water and backfilled to create a dock or pier. The backfill is sand or sand and gravel. Since it is difficult to compact the backfill below the water level, the backfill is often a loose, saturated sandy material which is vulnerable to liquefaction. The bulkheads can withstand the normal pressure of the fill, but if the backfill liquefies, the increase in lateral pressure can push the bulkhead outwards, often causing it to break.

Permits

Much of the East Bay shoreline is filled land. The chronology of the filling of land is covered in the accompanying report by Allison Turner.

After 1968, the Army Corps of Engineers required permits for any use in the area of its jurisdiction, which extends up to the mean high tide water line. Much of its jurisdiction overlaps with that of the San Francisco Bay Conservation and Development Commission (BCDC).

The BCDC shares its jurisdiction over land use decisions with the cities and counties, which retain their normal land use and building permit controls. A permit from BCDC is required for all projects within its jurisdiction, which extends up to 100 feet from water's edge. It issues permits only if they conform to guidelines stated in _The San Francisco Bay Plan_ (BCDC, 1969).

The Bay Plan recommends approval to fill if one of four conditions is met:

1. The filling is in accord with the Bay Plan policies as to the bay related uses for which filling may be needed, such as ports, water-related industry, and recreation, and is shown on the Bay Plan map as likely to be needed;

2. The filling is in accord with policies as to purposes for which some fill may be needed if there is no other alternative, such as airports, roads, and utility routes;

3. The filling is in accord with policies as to minor fills for improving shoreline appearance or public access, and;

4. The filling would provide for new public access to the Bay on privately owned property and for improvement of shoreline appearance in addition to what would be provided by the other Bay Plan policies, and the filling would be for bay-oriented commercial recreation and/or public assembly purposes.

The question of the safety of the fill must also be addressed before the BCDC can issue a permit. The BCDC makes the following findings:

> "Virtually all fills in the San Francisco Bay are placed on top of Bay mud which presents many engineering problems. The construction of a sound fill depends in part on the stability of the base upon which it is placed. Safety of a fill also depends on the manner in which the filling is done, and the materials used for the fill. Similarly, safety of a structure on fill depends on the manner in which it is built and the materials used in its construction. Construction of a fill or building that will be safe enough for the intended use requires (1) recognition and investigation of all potential hazards--including (a) settling of a fill or a building over a long period of time, and (b) ground failure caused by the manner of constructing the fill or by shaking during a major earthquake; and (2) construction of the fill or building in a manner specifically designed to minimize these hazards. While the construction of buildings on fills overlying Bay deposits involves a greater number of potential hazards than construction on rock or on dense hard soil deposits, adequate design measures can be taken to reduce the hazards to acceptable levels."

Potential Uses

The quality of a fill and its underlying foundation soil will determine its ability to support structures for different uses. There are four uses which may occur in the East Bay shoreline area: recreation, industry or commerce, residential, and no further development as in the case of preserving mudflats for wildlife.

Recreational areas are less sensitive to being placed on filled lands composed of a poor selection of fill materials. The added weight of recreational facilities is miniscule and shouldn't cause further consolidation on older filled areas. If the areas are to be newly filled, the most economical type of fill which can be used to support recreational facilities is garbage mixed with sand. The sand is necessary to fill the large voids in the garbage which would otherwise allow the garbage to compress and decompose internally. If part of the area to be filled is submerged, it should be raised above mean sea level with dredged mud and then covered with the garbage and sand.

Fills to be used for industrial and commercial purposes have to be "selected" and fairly incompressible. "Select" fill is well-graded with no large voids which

might allow the bay mud to squeeze upward into the fill material. Building loads, roads and utilities are necessary components of industrial and commercial uses, and the mud should not be deformed, if at all possible, to prevent differential settlement. The fill material should be incompressible so that future settlement due to the consolidation of the bay mud can be as predictable as possible. If new fills are to be placed, the surface should be brought above mean sea level by slow hydraulic dredging. Heavy fill materials such as rock are not advisable, because of the difficulty of placing them evenly. Sand is the most suitable type of fill for these purposes (Lee and Praszker, 1969).

Residential uses may be put on fill similar to the type of fill described above for industrial and commercial uses. The difference is that the avoidance of differential settlement is extremely important, because of the need for streets, utilities, and building foundations to remain in the same relative positions to one another. In new fills, the fill quality and method of placing should be strictly controlled to allow for uniform settlement over the entire area. Future settlement of new and older fills due to the imposed load of the development should be considered, so that when the streets, utilities, and house are placed, they are supported in a way which allows them to settle together at the same rate. If new fills are placed for the intended use of residential development, at least five years should elapse before any construction occurs (Lee and Praszker, 1969).

Major buildings as well as some small structures are supported on piles. The study of piles is complex. There are both pros and cons to using piles as foundations. Pile foundations can extend a certain distance into the mud (friction piles), or they can be bored through to the underlying firmer foundation soils. Friction piles are fairly strong, as the mud offers considerable resistance to impact loads. During earthquakes, the piles embedded in the mud will tend to vibrate with the mud. When the motion of the mud is opposite to that of the piles, the mud will flow around the piles, and it is unlikely that the piles will fail so long as the tips are free to rotate. When piles are driven into the underlying rock, earthquakes could cause critical problems. The mud and rock vibrate at different frequencies, which could cause the pile to break at the rock/bay mud interface. Piles have had a good record as far as withstanding earthquakes is concerned. During the 1906 quake, buildings supported by piles survived the earthquake; however, none of the piles were imbedded in the underlying bedrock.

The general practice for smaller one- or two-story structures is to place a blanket of carefully selected and compacted soil which is several feet thick over

the bay mud. The fill blanket acts as a mat, and light structures with conventional footings which rest on this mat should not settle differentially (Steinbrugge, 1969).

Smaller structures are more suitable to being placed on existing fills. During earthquakes, the frequency of the ground vibrations is low in bay mud. The taller a building is, the lower is its "natural" frequency of vibration. If the ground is vibrating at the same frequency as a building's "natural" frequency during an earthquake, the effect is to cause the building to vibrate even more violently. This can cause greater damage than would have been caused by the earthquake alone. A single-story building has a fundamental frequency of roughly 20 cycles/second, a ten-story building may have a frequency of 1 cycle/second, and a forty-story building may have a frequency of 0.25 cycles/second. To minimize the effects of ground shakings on buildings there should be a great difference between the fundamental frequency of the building and the frequency with which the ground shakes during an earthquake. Therefore the smaller structures with higher natural frequencies of vibrations would be the safest structures on fill covering bay mud. Tall buildings such as the buildings on the peninsula in Emeryville have to be designed to withstand the extra shaking they would experience during an earthquake.

Concluding Remarks

This report summarizes the hazards which may occur when developing on bay mud. The hazards include settlement over time, which is generally not uniform over a given area, and seismic hazards. Since the Bay Area has a past history of being seismically active, it is prudent to consider seismic hazards when doing any type of project on the filled lands of the East Bay shoreline. Before any construction or development is undertaken, several things must be considered:

1. A thorough test boring and soils engineering analysis of the soil characteristics must be taken;
2. Possibility of further settlement of older fill due to imposed loads;
3. Consideration of the effects of seismic activity on bay mud and therefore on structures which overlie it;
4. Foundations necessary to insure stability of a structure under settlement and seismic conditions;
5. Density of people using a structure who may be injured during an earthquake;
6. Possibility of liquefaction of foundation soils, lenses of liquefiable material such as sand in the bay mud, or of the fill material;

7. Necessity of the structure to be placed on the filled areas rather than on the natural lands further inland; and

8. Other considerations which soils engineers, building designers, City Planners, and other involved individuals feel are necessary to make developments of any sort as safe as possible.

Large earthquakes are expected to occur in the Bay Area once every 60 to 100 years. This is frequent enough to require that all structures and bay fills be designed to resist the forces of earthquakes. The historical record of earthquakes in the Bay Area has shown a greater seismic risk on bay fills overlying bay mud than on firmer soils, or on rock.

Newer fills, especially those constructed since the permit requirements of BCDC and the Army Corps of Engineers were implemented are quite different from the older fills. Experience with the performance of these newer fills under seismic conditions is very small, however. The experience from non-Bay Area fills under seismic conditions shows that newer well-compacted engineered fills perform much better than do uncontrolled fills, from which most of our knowledge of the performance of fills under seismic conditions comes.

Most of the proposed plans for the East Bay shoreline are for development of parks, refuges, and recreational facilities. These types of uses are fine for the area as it is, as most of the fills are older and have already undergone most of their critical settlement. Since these types of uses don't impose much of a load on the area, further settlement is unlikely, and the density of people using the area will be relatively low. In the case of a serious earthquake, injury will be minimal.

REFERENCES CITED

Blair, M.L., and W.E. Spangle, William Spangle and Associates (eds.), 1979. Seismic Safety and Land Use Planning - Selected Examples from California: U.S. Geological Survey Professional Paper 941-B: Washington, D.C., 82 pp.

Borcherdt, R.D. (ed.), 1975. Studies for Seismic Zonation of the San Francisco Bay Region: U.S. Geological Survey Professional Paper 941-A: Washington, D.C., 102 pp.

Borcherdt, R.D., E.E. Brabb, W.B. Joyner, E.J. Helley, K.R. LaJoie, R.A. Page, R.L. Wesson, and T.L. Youd. Predicted Geologic Effects of a Postulated Earthquake: U.S. Geological Survey Professional Paper 941-A, pp. 88-96.

Goldman, Harold B. (ed.), 1969. Geologic and Engineering Aspects of San Francisco Bay Fill, California Division of Mines and Geology Special Report 97: San Francisco, 130 pp.

(continued)

Goldman, Harold B., 1969. Geology of San Francisco Bay: California Division of Mines and Geology Special Report 97, pp. 31-41.

Lee, Charles H. and Michael Praszker, 1969. Bay Mud Developments and Related Structural Foundations: California Division of Mines and Geology Special Report 97, pp. 41-87.

San Francisco Bay Conservation and Development Commission (BCDC), 1969. San Francisco Bay Plan: San Francisco Bay Conservation and Development Commission, San Francisco, 43 pp.

Seed, Bolton H., 1969. Seismic Problems in the Use of Fills in San Francisco Bay: California Division of Mines and Geology Special Report 97, pp. 87-101.

Steinbrugge, Karl V., 1969. Seismic Risk to Buildings and Structures on Filled Lands in San Francisco Bay: California Division of Mines and Geology Special Report 97, pp. 101-117.

Youd, T.L., D.R. Nichols, E.J. Helley, and K.R. La Joie. Liquefaction Potential: U.S. Geological Survey Professional Paper 941-A, pp. 68-74.

SECTION II: WATER CIRCULATION AND SEDIMENTATION STUDIES BETWEEN ASHBY AND UNIVERSITY AVENUES

Chapter 1

WAVE PROCESSES IN THE BERKELEY EMBAYMENT

Peter K. Gee

Introduction

Waves are important in almost every physical process that takes place in the sea. A wave, in the form of an undulation moving across the surface of the water, is a conveyor of energy. It may be generated locally or several thousands of miles away in the ocean. Waves expend little energy in travel, and therefore expend most of it at the end of their journey, crashing upon a beach, breakwater, cliff or other landform.

The purpose of this study is to provide information on waves and their possible effects within the embayment between the Berkeley Marina and the Emeryville Marina, henceforth to be referred to as the Berkeley Embayment (FIGURE 1). Our interest in this area lies in recreation as well as in environmental quality, specifically for the shoreline between the Berkeley Marina and Ashby Spit. A beach has been proposed for this stretch by the Berkeley Beach Committee (Manning, 1979). Before any of the landfill took place in the 1950's, a beach existed north from University Avenue to Point Fleming, but much of the sand was sold and used for construction purposes. The proposal is an effort to "repair" environmental damage (the destruction of the beach and the placement of landfill) to West Berkeley. It is hoped to repair the coast with a minimum amount of money spent. However, without proper investigations of the physical processes involved, one cannot fill the shoreline with sand to make a beach, for the sand may not be compatible with the wave action and circulation in the water, and therefore may not stay in place. This study of waves and the following two on water circulation and sediment size analysis, by Linda Goad and Donald Bachman, respectively, are a start in determining whether or not a beach is feasible.

Wave Properties

An ideal wave train is a series of successive waves evenly spaced; each wave is equal, and there is no outside interference. Each wave has four principle characteristics: height, wavelength, period and velocity (Bascom, 1980; Russell and

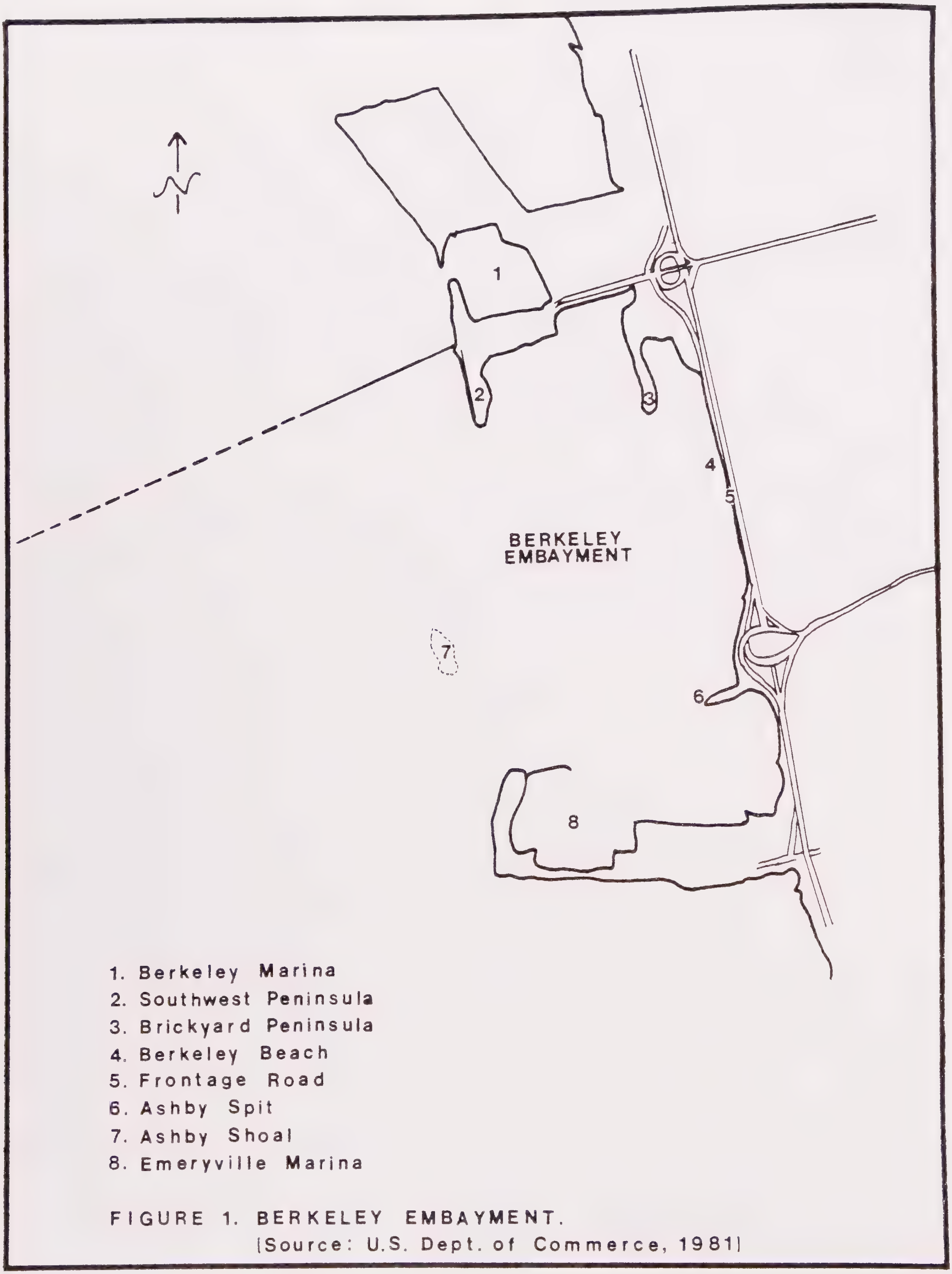


FIGURE 1. Berkeley Embayment.

Macmillan, 1952). Height (H) is the vertical distance between the crest and the trough of the wave, and wavelength (L) is the horizontal distance between adjacent crests or troughs. These are usually measured in feet. Ideally, these two characteristics are independent of each other, but in actual situations this rule does not hold true, as we shall soon see. The period (T) of a wave is the time in seconds between two successive crests past a fixed point; this is inversely related to the frequency (f), or the number of waves that pass a stationary point per unit time. Wave velocity (v) is the speed (and direction) which waves travel past a fixed point.

Under ideal conditions, velocity is equal to the wavelength divided by the period. However, the Berkeley Embayment, like any other marine body, is far from ideal. In actual conditions, velocity is given by the relation (Bascom, 1980)

$$v = \sqrt{gL/2\pi} \quad \text{or} \quad \sqrt{5.12L}$$

where g is the acceleration of gravity (32 ft/sec^2) and wavelength is given by the relation

$$L = (g/2\pi)T^2 \quad \text{or} \quad 5.12T^2.$$

The greater the wavelength, the greater the velocity. Furthermore, wave height is independent of wavelength only if it is not greater than one-seventh of the wavelength (Bascom, 1980); that is, the wave begins to break when wave steepness (H/L) exceeds 1:7.

Waves can be generated naturally by wind, seismic activity, or the gravitational pull of the moon and sun. Our study of the Berkeley Embayment is concerned with the most familiar kind, those generated by wind. Waves are created as the frictional drag of air moving across the water surface produces ripples. A higher surface tension increases the frictional drag with the air, and therfore enhances the response to the wind. Generally, the minimum wind speed to cause this response is 3.6 feet per second (Russell and Macmillan, 1952). Waves grow rapidly as the wind bears directly on the steep side of the ripples, which inturn allows for a more effective transferral of energy from air to water.

Factors that influence the size of wind waves are wind velocity, duration of the time the wind blows, and the distance over water in which the wind blows (the fetch). In the open ocean, waves grow to become stable swells, obtaining the maximum dimensions possible for the wind generating them; this result is known as a fully

developed sea (Bascon, 1980). Within the Berkeley Embayment, however, limits such as shallowness and nearness to the shore can counter the effects of the above factors. The shallowness reduces wave velocity, which brings about a proportionate decrease in wavelength, which in turn tends to increase the wave height (Russell and Macmillan, 1952). Even if the water were deeper, the short distance to shore would prohibit the full development of waves.

In addition to the surface motion of waves there exists an internal motion. Individual particles are said to be moving in circular orbits at a relatively constant rate and in one rotational direction (Wiegel, 1964). FIGURE 2 is an illustration of the orbital motion. When a crest is approaching, the particles are rising (a); when the crest is overhead, they are moving in the same direction as the wave (b); when the crest is leaving, the particles are falling (c); and when the trough is overhead, they are moving in the opposite direction to the waves (d).

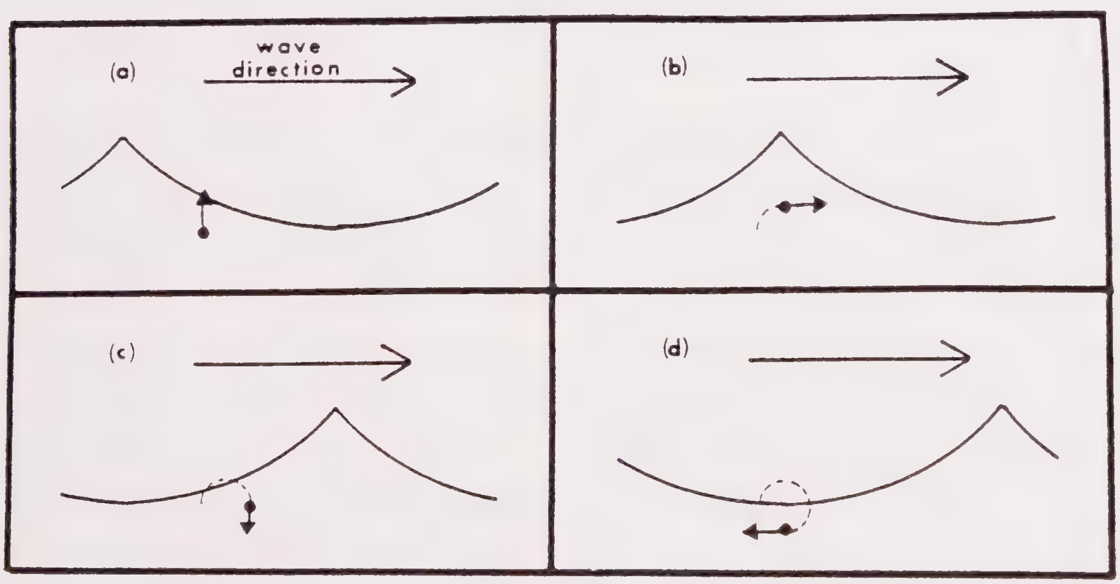


FIGURE 2. Orbital Motion of Water Particles.

All the orbits of particles in a vertical line are in phase. When the water is shallow, as in most of the Berkeley Embayment, vertical movement of the particles is restricted. The orbits become horizontal ellipses, each deeper ellipse flatter than the one above it, and the ellipse at the bottom being completely flattened out, such that the particle moves back and forth in a horizontal path. It is

important to note that these orbits are not completely closed, but instead new orbits are formed as particles have a net shift in the direction the wave travels. This forward motion of particles is called mass transport.

Waves in the Berkeley Embayment are a mixture of those propagated from the Pacific Ocean, waves generated over central San Francisco Bay, and locally-generated waves. Most of the waves are shallow-water waves, those that travel in water depths of less than one-half the wavelength. Thus, the way waves act depends on the basin as well as the wave characteristics.

As waves approach the shoreline, especially in shallow waters like the Berkeley Embayment, they reflect, diffract, and refract (Bascom, 1980; Wiegel, 1964). Reflection occurs when a wave encounters a vertical obstacle and is cast back with little loss of energy. Diffraction is the flow of energy perpendicular to the direction of wave motion, that is, the flow of energy laterally along the crest of a wave. This is responsible for waves propagating into otherwise sheltered regions. Waves are said to refract when they change directions due to a change in wavelength, which affects velocity. Wave fronts tend to become parallel to the shore because of the decreasing water depths which shorten wavelength.

Waves approaching the East Bay shoreline are reflected, diffracted and refracted by projections from the shore, such as the southwest peninsula of the Berkeley Marina landfill (FIGURE 1). Wave fronts from seven-feet deep water--measured at mean lower low tide (U.S. Department of Commerce, 1981)--reflect off the riprap along the west side of the peninsula near Seawall Drive (FIGURE 3). Diffraction of incident waves occurs close to the tip of the peninsula. To the south of the peninsula the waves are almost unaffected until the waves enter the geometric shadow of the landform. In this region the diffracted waves and the incident waves superimpose. In the geometric shadow northeast of the tip, the wave crests almost form the arc of a circle with its center at the peninsula tip. Refracted waves tend to contour around the peninsula, and are convex to the shoreline (FIGURE 4).

As waves approach the shore, wavelength and velocity decrease because of the shallowing basin, and thus, waves refract. The waves become steeper until the wave height becomes so great in relation to the water depth that the waves become unstable and break, releasing their energy in a tumultuous moment. This happens when the depth is roughly equal to 1.3 times the wave height (Bascom, 1980). In the case of the Berkeley Beach, breakers may occur 150 feet from the riprap bank along Frontage Road at low tide due to the shallow and level basin. The energy of the

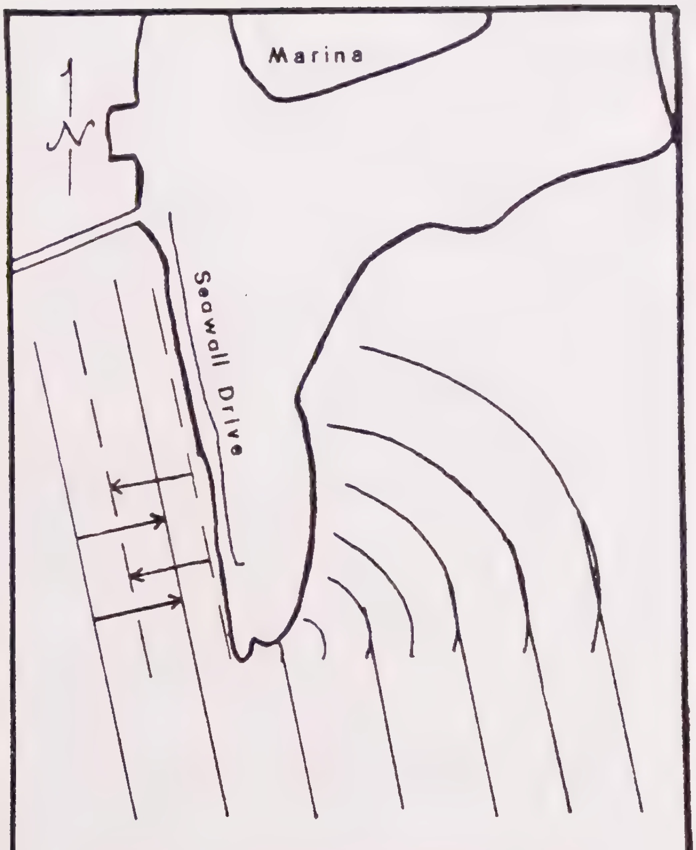


FIGURE 3. Wave Reflection and Diffraction

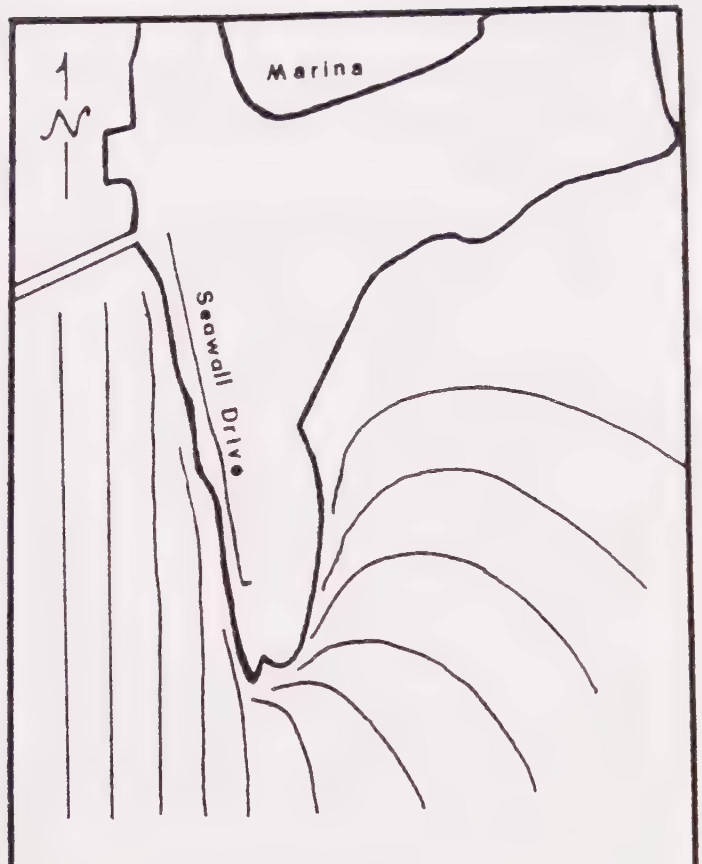


FIGURE 4. Wave Refraction

breaking waves suspends sand particles off the bottom and carries them shoreward. Depending on the wave action and the size of the sand particles, the particles may be carried seaward by the backwash. Wave action changes with the season. Waves are larger in the winter than in the summer, and therefore energy is expended on the beach at a higher rate in the winter. This energy erodes the beach, which is built by the mild summer waves too small to carry sand seaward in the backwash. Thus, it can be said of the wave-sand interaction: "The waves change the sand at the same time the sand is changing the waves" (Bascom, 1980, p. 219).

Although waves tend to become parallel to the shore as a result of refraction, this process is usually not complete. Breaking at an angle with the shore, waves usually produce a littoral current or a littoral drift. Combined with the continuous breaking of waves, the littoral drift is the primary means of transporting sand along the coast (Johnson and Wiegel, 1958). Particles suspended by breakers are relocated either by the littoral drift or a rip current (a continuous flow from the shore back to the sea through an eroded channel) (Bascom, 1980). These

natural processes, which move sand back and forth, are the foremost concern involved with artificially creating a beach, and without proper understanding and foresight, expensive erosion could result.

An example of an unsuccessful effort to create a beach is the Robert Crown Memorial Beach in Alameda. The park shoreline eroded over 250 feet in twelve years after it was built in 1958 (U.S. Army Corps of Engineers, 1979). The beach construction, an artificial fill of fine sand, was completed in 1959. Presently, little or no beach remains along Shoreline Drive, and the park facilities and the road are now in imminent danger of yielding to erosion. The San Francisco District, U.S. Army Corps of Engineers initiated a beach erosion control study in response to a 1968 request by the East Bay Regional Park District (EBRPD). Of eleven alternative plans of action to stabilize the beach, most of the desirable alternatives were too costly. For example, the cost of a plan similar to one supported by EBRPD (a series of spits or "sand catchers" and breakwaters) was estimated to exceed $6 million. Therefore, with the Alameda beach as an object lesson, certainly no beach should be instigated in Berkeley without substantial studies having taken place.

Methods

The data were collected intermittently in March, April and May. Our first step toward understanding wave conditions that would affect a Berkeley beach was measuring wave dimensions. Wave measurements were made in various locations within the Berkeley Embayment from a twelve foot motor boat, using a graduated staff. Initially, we tried to use the motor to stabilize the boat, while the staff was held vertically in the water. We had numerous problems with this, and other methods of measuring the waves, until our third outing, when we decided to inject the staff into the sediment below. Because the staff was now self-supporting, we could read wave height and frequency (per 60 seconds) without physically interfering with the measurements. We then calculated the other three wave dimensions, period, wavelength and velocity, from the relations

$$T = (f)^{-1}$$

$$L = 5.12T^2, \text{ and}$$

$$v = 5.12L \quad \text{respectively.}$$

Unlike a simple wave train, the sea is filled with all sorts of waves of different dimensions traveling in different directions at different speeds, all superimposed on the water surface. We felt there was a large degree of uncertainty over which waves to read. In our frustrations at trying to make some sense of the waves, we did not register the smaller waves in the data, nor did we take into account the crossing of the numerous different wave trains.

To get an idea of the littoral flow, we dropped fluorescene dye in the water and tried to follow its dispersal. The dye was bound in facial tissue to permit a single clean injection into the water; the tissue gradually dissolved and the dye slowly dispersed. The dye was dropped approximately twenty feet from the shore in two locations: one west of the southern portion of the Brickyard Peninsula and the other west of the central region of the proposed Berkeley Beach (FIGURE 1).

Wind speeds were measured with a wind anemometer, and both wind and wave directions were measured with a magnetic compass.

Results

Wave and wind data were collected over a period of two months and are summarized in TABLES 1 and 2, respectively. Wave directions were observed to be dominantly from the west, although sometimes they came from the northwest and the southwest. These directions were usually the same as those of the wind, which ranged in speed from 0 to 26 knots. Generally at higher wind speeds, the waves were pretty high, splashing over the side of the boat. On several occasions the wind speeds fluctuated throughout the day, and, correspondingly, the dimensions of the waves fluctuated. Such was the case on March 6. The wave data for the majority of that day are not shown on TABLE 1 because our technique of working with the graduated staff had not yet been perfected; the measurements listed for 4:15 p.m. were visual estimates. The waves for that day were observed as follows: at 9:30 a.m. the water was as smooth as glass, but by 1:30 p.m. the surface was all choppy water. At 2:43 p.m. the water was as calm as in the morning, but the wind had picked up again by 4:15 p.m. and had created ripples.

The tests with the fluorocene dye started twenty feet from the shore, which appears to have been too far away. Instead of a measure of littoral flow, the dye served to indicate a shorebound surface current, which we already knew from our drogue study (see Linda Goad's report). By the time the dye reached the shore, much of it had dispersed and was difficult to observe. We did, however, see that

DATE	TIME	HEIGHT AVG/MAX (IN)	FREQUENCY (SEC^{-1})	PERIOD (SEC)	WAVELENGTH (FEET)	VELOCITY (KNOTS)
2/27/82	-	-	-	-	-	-
3/06/82	4:15 p.m.	4/--	.57	1.8	15.9	5.4
3/12/82	9:00 a.m.	3/7	.73	1.4	9.5	4.1
	11:10 a.m.	4/8	.62	1.6	13.5	4.9
	1:50 p.m.	5/--	.75	1.3	9.1	4.0
	3:20 p.m.	9/15	.50	2.0	20.5	6.6
	4:30 p.m.	5/--	.50	2.0	20.5	6.6
4/09/82	6:30 a.m.	3/--	-	-	-	-
	2:15 p.m.	4/--	.78	1.3	8.5	3.9
4/17/82	8:50 a.m.	2/6	.68	1.5	11.0	4.4
	11:05 a.m.	4/--	.90	1.1	6.3	5.7
	1:30 p.m.	7/15	.67	1.5	11.5	4.5
5/14/82	10:05 p.m.	6/12	.67	1.5	11.5	4.5
	11:40 p.m.	6/10	.67	1.5	11.5	4.5

- = no data

TABLE 1. Wave Data.

DATE	TIME	DIRECTION (FROM)	SPEED (KNOTS)	GUSTS (KNOTS)
2/27/82	-	-	-	-
3/06/82	8:30 a.m.	NE	15.1	-
3/12/82	9:46 a.m.	NW	7.3	-
	12:42 p.m.	WNW	8.1	-
	1:35 p.m.	W	7.6	-
	3:20 p.m.	W	15.6	18.3
	4:30 p.m.	W	18.3	21.0
4/09/82	6:30 a.m.	N	3.8	-
	8:25 a.m.	W	1.1	-
	12:30 p.m.	SW	3.2	-
	2:15 p.m.	W	6.5	-
4/17/82	8:50 a.m.	WSW	2.7	5.4
	11:05 a.m.	WSW	7.3	-
	1:30 p.m.	W	13.0	-
5/14/82	11:40 a.m.	SW	4.3	-

- = no data

TABLE 2. Wind Data.

some dye moved equally north and south along the shore of the Brickyard Peninsula, and north along the proposed Berkeley Beach. We did not record any rates of littoral flow because we could not visibly determine the front of the dye mass in solution.

Discussion

The Berkeley Beach is exposed to steady wave action. Although the largest waves I recorded from March to mid-May were fifteen inches high, an overall average height for this time is approximately four to five inches. Wave velocities averaged seven feet per second, or 4.2 knots, and the periods averaged 1.5 seconds each. Apparently these waves were wind waves generated over the central bay; ocean waves would have had a much longer period (fifteen to twenty seconds) and, since they funnel through the Golden Gate Strait, would lose most of their energy to diffraction (Pirie, pers. comm., 1982). Wind waves of this size don't appear to pose much of a problem for a beach if the grain size is coarse.

The even dispersal in both directions of the fluorecene dye along the Brickyard Peninsula indicates no littoral drift at the time of the test, which was mid-ebb tide. The northward dispersal along the central Berkeley Beach suggests a northward littoral drift. However, to measure a net littoral flow, experiments would have to be conducted repeatedly during all tide conditions. Since our experiment was conducted only on one mild ebb (the tidal difference was 4.1 feet), I cannot make any conclusions about the net littoral drift.

Although I recorded a maximum wind velocity of 26 knots, which does not seem to create substantial waves to deteriorate a beach of coarse sand grains, I must add that I was unable to collect data during the fierce storm at the end of March. Storms move most of the sediment away from a beach, and having collected no data in storm conditions, which are frequent in winter, I cannot infer much about the overall stability of the Berkeley Beach. Furthermore, during winter, the winds often blow from the east or southeast (Conomos, 1979), which will have different effects on the wave-sand interaction than the westerlies I recorded. I would contend that a Berkeley Beach can be stable through calm seasons in March, April and May, but, obviously, a beach must be stable year-round. I would certainly like to see a beach in Berkeley, but since so many interested groups of people are involved and so much money is at stake, I would suggest the wave experiments be conducted over a period of several years, so that assurance can be expressed before any beach construction takes place.

REFERENCES CITED

Bascom, Willard, 1980. Waves and Beaches: 2nd Edition, New York, Anchor Press/Doubleday, 366 pp.

Conomos, T.J., 1979. Properties and Circulation of San Francisco Bay Waters, pp. 47-84 in Conomos, T.J., ed., San Francisco Bay: The Urbanized Estuary, American Association for the Advancement of Science, San Francisco, California, 493 pp.

Johnson, J.W. and R.L. Wiegel, 1958. Investigation of Current Measurement in Estuarine and Coastal Waters: Berkeley, California State Water Pollution Control Board, Standard Service Agreement No. 12C-18, 233 pp.

Manning, Curt, 1979. The Reconstruction of Berkeley Beach: Oakland, Penthouse Printing, 14 pp.

Pirie, Douglas, Coastal Engineer, U.S. Army Corps of Engineers. Personal communication, February 12 and May 19, 1982.

Russell, R.C.H., and Commander D.H. Macmillan, 1952. Waves and Tides: London, Hutchinson's Scientific and Technical Publications, 348 pp.

U.S. Army Corps of Engineers, 1979. Study of Beach Erosion Control, City of Alameda: San Francisco, Corps of Engineers, 40 pp.

U.S. Department of Commerce, 1981. Nautical Chart 18649: San Francisco Entrance, Washington, D.C., National Oceanic and Atmospheric Administration, National Ocean Survey.

Wiegel, Robert L., 1964. Oceanographical Engineering: London, Prentice-Hall, Inc., 532 pp.

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Chapter 2

WATER CIRCULATION PATTERNS BETWEEN UNIVERSITY AVENUE AND ASHBY AVENUE

Linda Goad

Introduction

The purpose of this study is to determine a general water circulation pattern for the surface waters in and around the embayment between the Berkeley Marina and Emeryville Marina (see map, page vi). This area was chosen because it is part of a proposed East Bay Shoreline Park that is being considered by the State Department of Parks and Recreation and the State Coastal Conservancy, and because there is a proposal to develop a beach between Ashby Avenue and University Avenue. Water circulation patterns need to be studied in order to determine what effects they will have on the stability of the proposed beach.

This study area is part of the complex San Francisco Bay estuary. Water circulation in estuaries differs from that of the open ocean, and a few general properties will be discussed below.

General Properties of Estuarine Water Circulation

Estuaries are dynamic entities. The ebb and flow of waters from the ocean meet and mix with the fresh waters draining from the land. There are many definitions for the term "estuary," but the most commonly accepted is that of Pritchard: "An estuary is a semi-enclosed coastal body of water which has a free connection with the open sea and within which sea water is measurably diluted with fresh water derived from land drainage" (1967, p. 3).

Many physical processes affect the behavior of an estuary, including tidal influence, river inflow, and wind action. The waters are mixed primarily by tides; the river discharge produces a net outflow of these waters, thereby flushing the estuary (McCulloch et al., 1970). In San Francisco Bay, river inflow and wind are also major causes of mixing (Conomos, 1979).

Estuaries can be classified in a number of ways depending on geometric and bathymetric configuration, physical oceanographic characteristics of circulation and mixing, or both. If estuaries are classified by their circulation patterns,

the cause of the water motion is used as the classifying principle. The three main causes are the wind, the tide, and the river.

Pritchard (1955) classified estuaries based on the advection-diffusion equation for salt which states that the time rate of change observed in the salinity at a fixed point is caused by two different physical processes--advection and diffusion. Advection leads to a mass flux of water as well as a flux of salt, while diffusive processes are associated only with a flux of salt. The advective processes are associated with the net circulation pattern, and the diffusive processes with turbulent or eddy mixing. A classification is derived by grouping together all estuaries in which the changes in salinity are produced mainly by the same causes. With this kind of classification, there is a sequence of estuarine types with a different circulation pattern; any estuary may pass through this sequence as conditions change.

Estuaries can be classified into four main types, ranging from the highly stratified salt wedge estuary to the well mixed, vertically homogeneous estuary (Pritchard and Carter, 1971). The Type A, or salt wedge, estuary belongs to the river-dominated category and is highly stratified. The Type B, or partially mixed estuary, is sufficiently influenced by the tide to prevent the river from dominating the circulation if the volume flow of the tidal oscillation is much greater than the volume flow of the river. The salt wedge is erased by the added turbulence of the tidal flow; salt water is mixed upward and fresh water is mixed downward. The difference between the surface and bottom salinities remains substantially constant over the estuary. In a Type C estuary, tidal velocities are further increased, and the water becomes vertically homogeneous. A Type D estuary is one in which the tide is so large in relation to the river that it almost overwhelms the effect of the river flow. This is a sectionally homogeneous estuary, in which the salinity is homogeneous both laterally and vertically (Pritchard and Carter, 1971).

Factors Affecting Nearshore Circulation of Estuaries

Several factors affect the pattern of nearshore circulation in estuaries. These include the effects due to tides and tidal currents, wind currents, longshore currents, flushing by rivers, and various obstructions.

Tides are movements of the oceans set up by the gravitational effects of the sun and moon in relation to the earth. Tides are important in estuarine geomorphology because currents are generated as the tide ebbs and flows. Tides move

in harmony with the gravitational forces of the sun and the moon, and their effects are seen most strongly in shallow and relatively enclosed ocean areas (Bird, 1968).

Currents can also be generated by the wind. When wind blows over water, it tends to drag the surfact particles of the water along with it. Thus, the water surface acquires a motion in the direction of the wind, although the velocity of the water never equals that of the wind (Johnson, 1965). In an estuarine system, tidal currents predominate under normal weather conditions, but strong winds and freshets can bring about nontidal currents, which can modify considerably the speeds and directions of the tidal currents. Currents generated by wind and tide can be strong enough to move surficial sediment on the sea floor. Relatively weak currents can transport sediment in the nearshore zone (Bird, 1968). Currents are also responsible for the various kinds of ripple patterns on tidal flats and on the floors of estuaries.

Longshore currents play an important part in the longshore movement of material, thereby contributing to the formation of many coastal features. The volume and velocity of river flow also plays an important part in determining where the fresh water and salt water will mix. The relative strengths of the river flow and the tidal flow are primarily responsible for the net nontidal estuarine circulation pattern. This net nontidal circulation is important in determining the rate of infilling of most estuaries (Schubel, 1971).

Points, breakwaters, and piers all influence the circulation pattern and alter the direction of the currents flowing along the shore. Generally these obstructions determine the position of one side of the circulation cell. Where prominent points of land interrupt the predominant longshore current flow, currents opposite in direction are likely to develop in the current lee of the point (Shepard and Inman, 1960).

San Francisco Bay Estuary

San Francisco Bay is a complex estuary that is in part a Type B estuary which at certain seasons assumes characteristics of a Type A or Type C estuary. It consists of many interconnected embayments, rivers, marshes, and sloughs (FIGURE 1). This estuarine system is unusual in that it consists of two hydrodynamically and geographically distinct reaches, the norther reach which includes the area south and westward from the Delta to the Golden Gate, and the southern reach which extends from the San Francisco-Oakland Bay Bridge south to San Jose. The waters of the San Francisco Bay are a combination of ocean, river, and effluent discharges. The

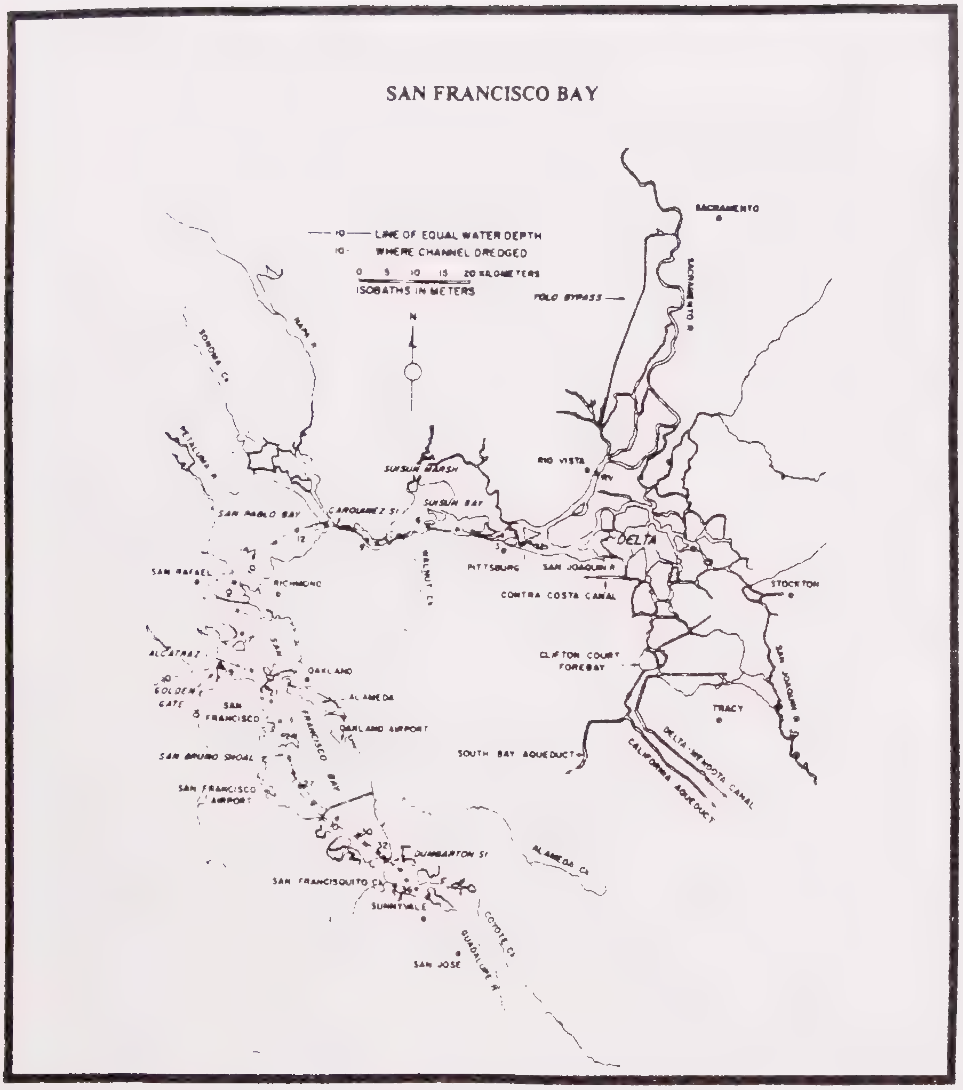


FIGURE 1. The San Francisco Bay-Delta System.
Source: Conomos, 1979.

ratios of these waters and their compositions are continually changing depending on various factors, including amount of river flow, time of year, amount of waste discharge, configuration of the estuary, winds, and tidal influence.

The principal river flow into the bay is from the Sacramento and San Joaquin Rivers. The norther reach receives 90 percent of the mean annual river inflow and 24 percent of the total wastewater inflow into the bay. The variations in water properties in the south bay are determined by water exchange from the north and the ocean, and by waste inflow (76 percent of the total wastewater inflow) (Conomos, 1979).

The basic circulation patterns in the bay are tidally induced and are relatively unchanging throughout the year (Conomos, 1979). Tides in the bay are mixed and semi-diurnal; two low and two high tides occur each tidal day (24.84 hrs.). The high tides are unequal in height, as are the low tides (Conomos, 1979). Within the bay, the tides create reversing currents that are strongest in the channels and

weaker in the shoals. The nontidal currents are generated by winds and river flow and are important in transporting dissolved and particulate substances into and from the bay.

Methodology

This study consisted of measuring the speed and direction of surface water currents for the area between the Berkeley Marina and the Emeryville Marina in the central bay. Due to time constraints and technical difficulties, bottom currents could not be measured, although they are important in the transportation of sediment. To date, no detailed studies have been conducted on the circulation patterns in the study area; our field study is thus a first attempt.

There are two general methods for directly measuring currents (von Arx, 1962). Eulerian methods consist of measuring the flow of water past a fixed point using a current meter which records the speed and direction of flow. Lagrangian methods track a parcel of water in space and time using a tracer. Devices that can be used as tracers are drift bottles, radio buoys, current poles, drogues, or floats.

The Lagrangian method of measuring currents was used for this study. Drogues were used to track the parcel of water. The drogue consisted of a ½-liter plastic soda bottle filled with approximately 9 ounces (by volume) of dry sand as ballast. Two yellow flags were taped together and inserted through a small hole in the bottle cap. A 4½-inch length of fluorescent orange tape was fixed to the stem of the flags for easier visibility. Most of the bulk of the drogue rode below the surface of the water, away from the direct effects of the wind.

Studies were conducted on four days: February 26, March 6, March 12, and April 17, 1982. A small motorboat was used for following the drogues. Sextants were used to locate drogue positions. Successive readings of drogue positions were taken until the drogues were picked up just prior to beaching. Speed of drogues for each study day are given in Appendix A, which also lists which drogues were beached before being picked up, which drogues were not recovered, and which traveled out of the study area. Two of the studies were conducted under ebb tide conditions and two were conducted under flood tide conditions.

A number of problems occurred throughout the study. Almost all of the drogues from the first study day were beached before being picked up. Consequently, the time of beaching could not be recorded, and the time it took a drogue to reach the beach from its last recorded position could not be determined. Several drogues became lost and were not recovered. A number of drogues from the first study day

drifted south of the Emeryville Marina out of the study area (see Appendix).

Results

The weather was slightly overcast or clear on all four study dates. Winds were variable, ranging from calm to about 13.5 knots. FIGURES 2 through 5 show the placement of drogues and the direction of drogue movement. The following is a brief summary of the results of this study.

Saturday, February 17, 1982 (FIGURE 2): Thirty-five drogues were released starting from about 9/10 of a mile from shore at H's Lordships restaurant to the north tip of the Emeryville Marina. The first drogue was released at 9:10 a.m., one hour after low tide. Most of the drogues were picked up by the time high tide occurred at 2:33 p.m. No wind data were taken for this day. The drogues moved southeast into shore at about .40 knots. Those that reached the Emeryville breakwater continued to move shoreward along the breakwater. There was a slight tendency for the drogues to move in a counter-clockwise fashion as they headed for shore.

Saturday, March 6, 1982 (FIGURE 3): Twenty-four drogues were released in a line starting from Shorebird Park cove (see map, page vi) to a point about 200 yards north of the Cutter Building at the Emeryville Marina. The wind was calm at the start of the study. The first drogue was released shortly before high tide at 8:57 a.m. The drogues were picked up by 1:00 p.m.; low tide occurred at 3:45 p.m. The drogues started heading northwest and then circled clockwise to head northeast to shore. Those drogues in the Shorebird Park cove area tended to describe a tighter clockwise pattern. Drogues farther from shore or obstructions generally moved at about .32 knots; those in the cove area moved at about .2 knots.

Friday, March 12, 1982 (FIGURE 4): Sixteen drogues were released in a line from H's Lordships restaurant to a point approximately two-thirds of a mile south towards the Emeryville Marina. Low tide occurred at 7:34 a.m., and high tide occurred at 1:57 p.m. The first drogue was set out at 9:17 a.m., approximately halfway between low and high tide. All drogues were picked up by 12:30 p.m. Wind speed at 9:46 a.m. was 6.5-8 knots. Wind speed at 12:42 p.m. was 7.5-9 knots from the northwest. All drogues moved southeast to the shoreline in a slightly counter-clockwise fashion. The speed was about .34 knots. In general, the drogues moved in the same direction as those in the study conducted on February 27.

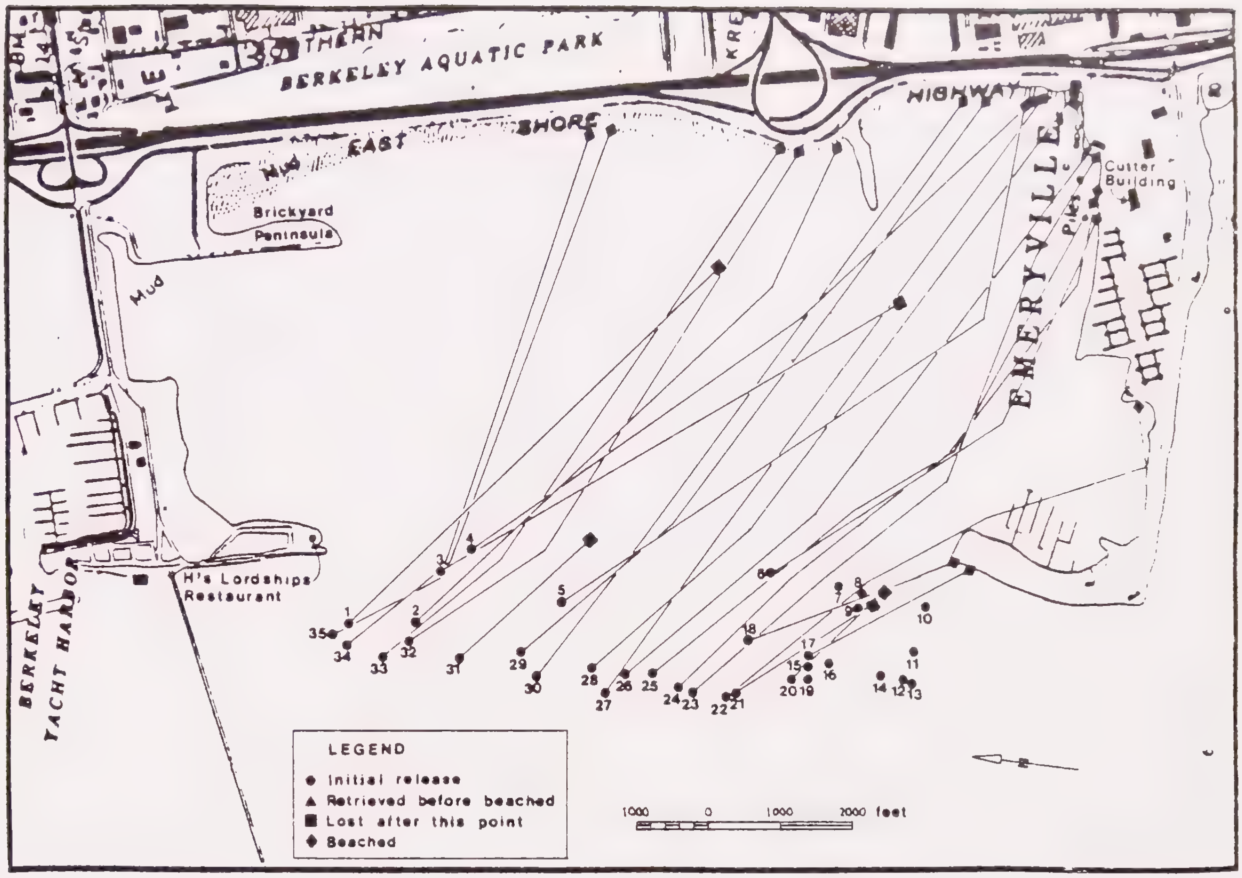


FIGURE 2. Location of Drogue Releases and Pattern of Movement for February 27, 1982.

NOTE: Drogues with no tracking pattern were lost after initial release or traveled out of the study area.

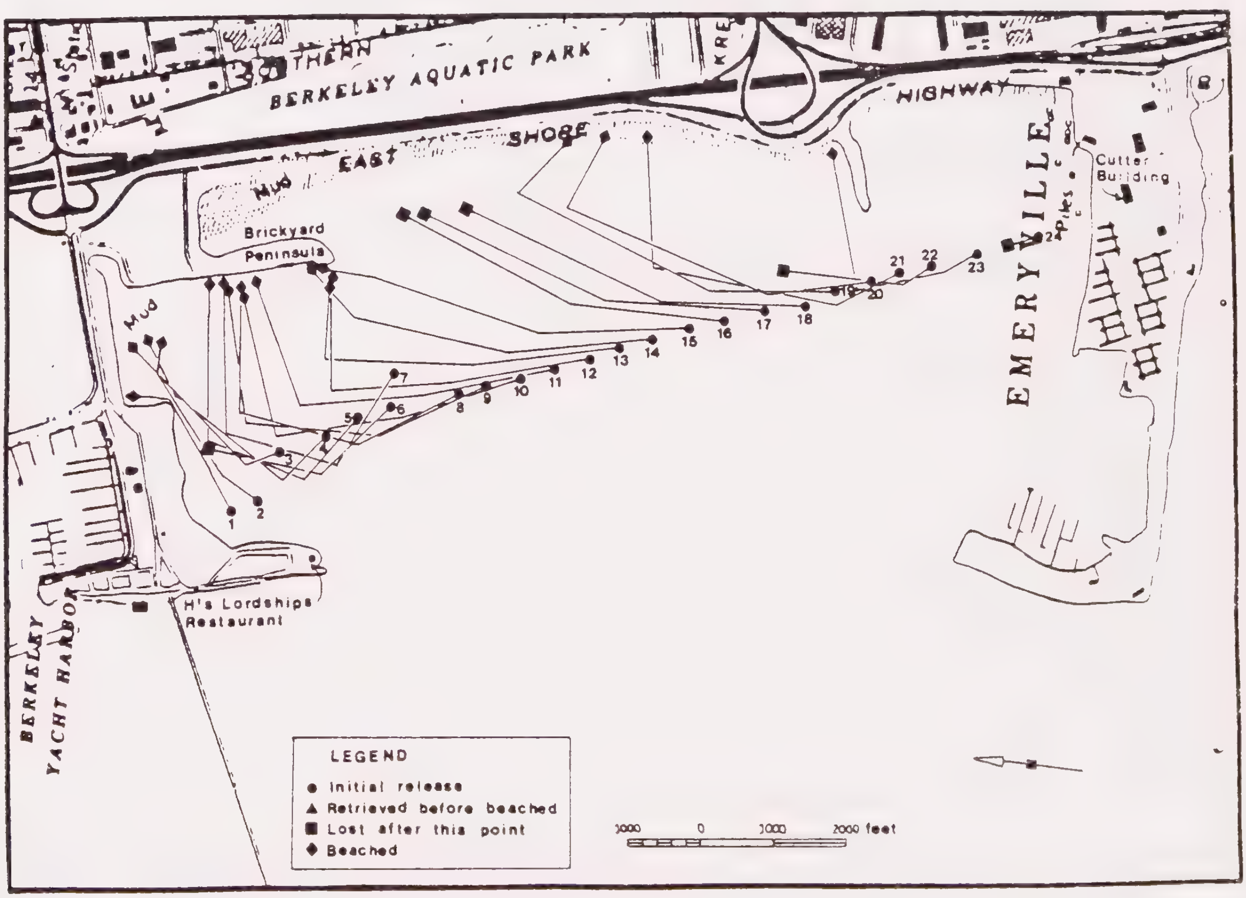


FIGURE 3. Location of Drogue Releases and Pattern of Movement for March 6, 1982.

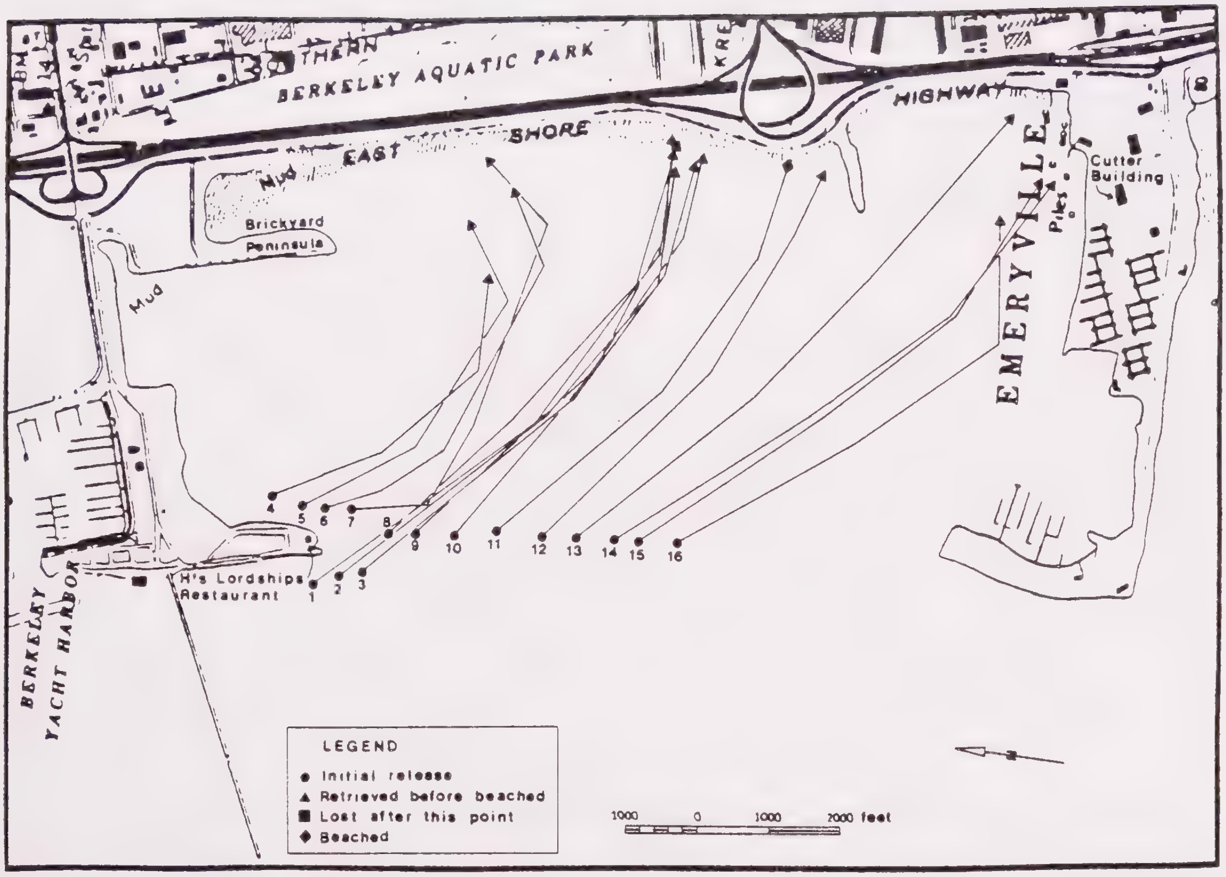


FIGURE 4. Location of Drogue Releases and Pattern of Movement for March 12, 1982.

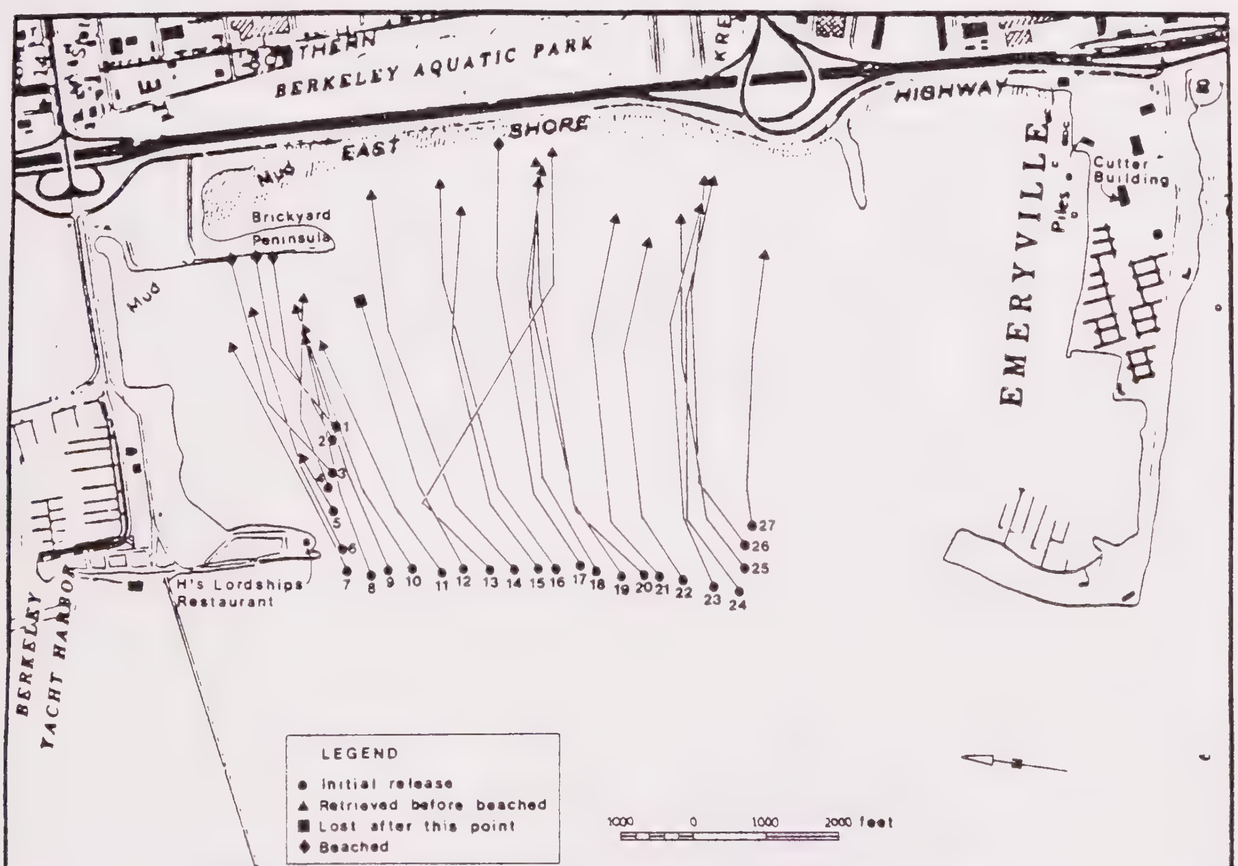


FIGURE 5. Location of Drogue Releases and Pattern of Movement for April 17, 1982.

Saturday, April 17, 1982 (FIGURE 5): Seven drogues were set out in a line between the Brickyard peninsula and H's Lordships restaurant; twenty drogues were then set out in a line from H's Lordships to a point two-thirds of the way to the Emeryville Marina. High tide occurred at 6:14 a.m., and low tide occurred at 1:15 p.m. The first drogue was released at 9:30 a.m., about halfway between the high and low tides. All drogues were picked up by the beginning of the low tide. Wind speed was 2.7-5.4 knots from the southwest at 8:50 a.m. Wind speed was 10.8-13.5 knots from the west at 1:30 p.m. The drogues at first moved northeast to shore in a slightly clockwise motion and then moved due east straight in to shore. The average speed was about .2 knots.

Discussion

Surface currents in the study area are affected by the tides and winds. It was not possible to determine the effects of each separately; consequently, the speed and direction measurements of the drogues represent a net circulation pattern.

In order to put together a comprehensive picture of water circulation patterns in an area, studies should be conducted under different climatic conditions, seasons, tidal cycles, and wind directions and speeds. Due to time constraints, my study could only be conducted under different tidal cycles. Consequently, it should be kept in mind that results from these studies apply only to this limited situation. It is also desirable to map out a grid system for an initial release of drogues at predetermined spots and reoccupy those stations at different study dates in order to compare results from different studies. This was not possible to do; using sextants to locate a predetermined position is extremely difficult and time consuming. But for comparison of general circulation patterns, the additional variable of different initial drogue release positions may not be very significant.

Regardless of the part of the tidal cycle during which the study was conducted, all drogues moved shoreward; no drogues moved seaward. In general, when the tide was moving in, the drogues moved southeast to the shore. When the tide was going out, the drogues moved northeast to shore. In the more open areas of the embayment, the drogues described a very slight clockwise or counter-clockwise tendency. In the more confined areas, the drogues described tighter circular patterns. It appears that the drogues moved faster when the tide was coming in than going out. In addition, many drogues moved faster the closer they came to shore.

The surface currents were moving slowly. There was a tendency for wind stress on the water surface, which had an effect on the direction of the surface currents

(Pirie, pers. comm., 1982). On the days of this study, surface water circulation probably had little effect on sediment movement. Waves will have a much greater effect on sediment movement than the currents (see paper by Peter Gee).

Conclusion

Before a beach can be established in this study area, it will be essential to undertake numerous additional studies--my particular effort was just a beginning. Bottom currents, especially, need to be studied. While the embayment is somewhat sheltered and at a distance from the Sacramento and San Joaquin Rivers, it is conceivable that there could be some river water influence on the currents in this area. Studies could also be conducted on the possible influence of storm drain and creek outflow that drain directly into the area; the movement of longshore currents also needs to be studied. In addition, more detailed studies of the circulation around the Brickyard peninsula and other obstructions should be done.

Sediment movement is a complex process that is affected by many factors, of which water circulation is only one. Under different physical conditions, or time of year, different results may be obtained, with different conclusions reached.

Acknowledgments

I would like to thank Peter Gee and Don Bachman for their help in conducting these studies; Douglas M. Pirie and George W. Domurat of the U.S. Army Corps of Engineers for their help in setting up this study and interpretation of results; and QMC R.W. Scott of U.C. Berkeley's Department of Naval Science for the use of the sextants.

REFERENCES CITED

Bird, E.C.F., 1968. Coasts: Canberra, Australian National University Press, 246 pp.

Conomos, T.J., 1979. Properties and Circulation of San Francisco Bay Waters, pp. 47-84 *in* Conomos, T.J., ed., San Francisco Bay, the Urbanized Estuary, Am. Assoc. Adv. of Sci., San Francisco, CA, 493 pp.

Johnson, Douglas Wilson, 1965. Shore Processes and Shoreline Development: New York, Hafner Publishing Company, 584 pp.

McCulloch, D.S., D.H. Peterson, P.R. Carlson, and T.J. Conomos, 1970. A Preliminary Study of the Effects of Water Circulation in the San Francisco Bay Estuary: U.S. Geological Survey Circular 637-A, B, 34 pp.

Pirie, Douglas M., Coastal Engineer, U.S. Army Corps of Engineers. Personal communication, May 19, 1982.

Pritchard, D.W., 1955. Estuarine Circulation Patterns: Proc. Am. Soc. Civil Eng., v. 81, Separate No. 717, 427 pp.

Pritchard, D.W., 1967. What Is an Estuary: Physical Viewpoint, pp. 3-5 in Lauff, George H., ed., Estuaries, Amer. Assoc. Adv. of Sci., Pub. No. 83, Washington, D.C. 757 pp.

Pritchard, D.W. and H.H. Carter, 1971. Estuarine Circulation Patterns, pp. IV-1 to IV-17 in Schubel, J.R., ed., The Estuarine Environment, American Geological Institute, Washington, D.C., 339 pp.

Shepard, F.P. and D.L. Inman, 1950. Nearshore Circulation: Proc., First Coastal Eng. Conf. Univ. Calif., 1950, pp. 50-59.

von Arx, William S., 1962. An Introduction to Physical Oceanography: Reading, Massachusetts, Addison-Wesley Publishing Company, Inc., 422 pp.

APPENDIX

DROGUE TRACKING TABLE

DATE: February 27, 1982

	Speed (Knots)				
Drogue #	Pt. 1 to Pt. 2	Pt. 2 to Pt. 3	Pt. 3 to Pt. 4	Pt. 4 to Pt. 5	Comments
1	.45	-	-	-	Lost after Pt. 2
2	.44	-	-	-	Beached after Pt. 2
3	.47	-	-	-	Lost after Pt. 2
4	.39	-	-	-	Beached after Pt. 2
5	.49	-	-	-	Beached after Pt. 2
6	.23	.23	-	-	Beached after Pt. 3
7	-	-	-	-	Lost after initial release
8	-	-	-	-	Lost after initial release
9	-	-	-	-	Traveled out of study area
10	-	-	-	-	Traveled out of study area
11	-	-	-	-	Traveled out of study area
12	-	-	-	-	Traveled out of study area
13	-	-	-	-	Traveled out of study area
14	-	-	-	-	Traveled out of study area
15	-	-	-	-	Traveled out of study area
16	-	-	-	-	Lost after initial release
17	-	-	-	-	Lost after initial release
18	.26	-	-	-	Beached after Pt. 2
19	-	-	-	-	Beached after initial release
20	.20	-	-	-	Lost after Pt. 2
21	.28	-	-	-	Lost after Pt. 2
22	.30	.27	-	-	Beached after Pt. 3
23	.29	.36	.27	-	Beached after Pt. 4
24	.28	.41	.32	-	Beached after Pt. 4
25	.42	.40	-	-	Beached after Pt. 3
26	.56	-	-	-	Beached after Pt. 2
27	.50	-	-	-	Beached after Pt. 2
28	.54	-	-	-	Beached after Pt. 2
29	.55	-	-	-	Beached after Pt. 2
30	.51	-	-	-	Beached after Pt. 2
31	.54	-	-	-	Lost after after Pt. 2
32	.52	-	-	-	Beached after Pt. 2
33	.51	-	-	-	Beached after Pt. 2
34	.52	-	-	-	Beached after Pt. 2

APPENDIX

DROGUE TRACKING TABLE

DATE: March 6, 1982

Drogue #	Speed (Knots) Pt. 1 to Pt. 2	Pt. 2 to Pt. 3	Pt. 3 to Pt. 4	Pt. 4 to Pt. 5	Comments
1	.10	.23	-	-	Beached after Pt. 3
2	.10	.22	-	-	Beached after Pt. 3
3	.08	-	-	-	Beached after Pt. 2
4	.14	.24	-	-	Beached after Pt. 3
5	.20	.19	-	-	Beached after Pt. 3
6	.23	.21	-	-	Lost after Pt. 3
7	.26	.21	-	-	Beached after Pt. 3
8	.28	.22	-	-	Beached after Pt. 3
9	.29	.26	-	-	Beached after Pt. 3
10	.31	.23	-	-	Beached after Pt. 3
11	.34	.22	-	-	Beached after Pt. 3
12	.36	.21	-	-	Beached after Pt. 3
13	.37	.25	-	-	Beached after Pt. 3
14	.36	.28	-	-	Beached after Pt. 3
15	.37	.31	-	-	Beached after Pt. 3
16	.38	.32	-	-	Lost after Pt. 3
17	.40	.33	-	-	Lost after Pt. 3
18	.36	.36	-	-	Lost after Pt. 3
19	.31	.37	-	-	Beached after Pt. 3
20	.26	.37	-	-	Beached after Pt. 3
21	.17	.32	-	-	Beached after Pt. 3
22	.08	.18	-	-	Lost after Pt. 3
23	.09	.14	-	-	Beached after Pt. 3
24	.02	-	-	-	Lost after Pt. 2

APPENDIX

DROGUE TRACKING TABLE

DATE: March 12, 1982

	(Speed (Knots)				
	Pt. 1	Pt. 2	Pt. 3	Pt. 4	
Drogue #	Pt. 2	Pt. 3	Pt. 4	Pt. 5	Comments
1	.54	.47	.25	-	Retrieved at Pt. 4
2	.53	.45	.23	-	Retrieved at Pt. 4
3	.55	.43	.25	-	Retrieved at Pt. 4
4	.18	.17	.21	.15	Retrieved at Pt. 5
5	.21	.19	.23	.18	Retrieved at Pt. 5
6	.20	.26	.27	.20	Retrieved at Pt. 5
7	.25	.32	.27	.21	Retrieved at Pt. 5
8	.45	.50	.26	-	Retrieved at Pt. 4
9	.56	.40	.22	-	Retrieved at Pt. 4
10	.55	.41	.20	-	Retrieved at Pt. 4
11	.51	.40	-	-	Retrieved at Pt. 3
12	.55	.38	.26	-	Retrieved at Pt. 4
13	.53	.35	.28	-	Retrieved at Pt. 4
14	.53	.34	.26	-	Retrieved at Pt. 4
15	.52	.33	.25	-	Retrieved at Pt. 4
16	.46	.34	.20	-	Retrieved at Pt. 4

APPENDIX

DROGUE TRACKING TABLE

DATE: April 17, 1982

	Speed (Knots)				
Drogue #	Pt. 1 to Pt. 2	Pt. 2 to Pt. 3	Pt. 3 to Pt. 4	Pt. 4 to Pt. 5	Comments
1	.22	-	-	-	Beached after Pt. 2
2	.21	-	-	-	Beached after Pt. 2
3	.22	-	-	-	Beached after Pt. 2
4	.15	.15	-	-	Retrieved at Pt. 3
5	.15	-	-	-	Retrieved at Pt. 2
6	.20	.19	-	-	Retrieved at Pt. 3
7	.18	.19	-	-	Retrieved at Pt. 3
8	.20	.18	-	-	Retrieved at Pt. 3
9	.23	.22	-	-	Retrieved at Pt. 3
10	.20	.21	-	-	Retrieved at Pt. 3
11	.17	.20	-	-	Retrieved at Pt. 3
12	.20	.25	-	-	Lost after Pt. 3
13	.20	.24	.27	-	Retrieved at Pt. 4
14	.17	.21	.27	-	Retrieved at Pt. 4
15	.16	.18	.26	-	Retrieved at Pt. 4
16	.21	.24	.23	-	Retrieved at Pt. 4
17	.18	.23	-	-	Beached after Pt. 3
18	.21	.19	.27	-	Retrieved at Pt. 4
19	.17	.22	.29	-	Retrieved at Pt. 4
20	.18	.11	.26	-	Retrieved at Pt. 4
21	.14	.19	.41	-	Retrieved at Pt. 4
22	.15	.16	.24	-	Retrieved at Pt. 4
23	.14	.23	.24	-	Retrieved at Pt. 4
24	.17	.20	.28	-	Retrieved at Pt. 4
25	.11	.16	.25	-	Retrieved at Pt. 4
26	.14	.19	.26	-	Retrieved at Pt. 4
27	.06	.13	.21	-	Retrieved at Pt. 4

Chapter 3

SEDIMENTATION ANALYSIS OF THE ASHBY SHOAL AND THE SHORELINE BETWEEN THE EMERYVILLE AND BERKELEY MARINAS

Don Bachman

Introduction

Before the construction of Interstate 80 and the Berkeley and Emeryville Marinas, Berkeley's shoreline north of University Avenue consisted of a sandy beach (Manning, 1982, pers. comm.). Development along the waterfront has greatly changed the beach accretion and erosion processes. Curt Manning, of the Berkeley Beach Committee, has proposed the reconstruction of a "Berkeley Beach" between the tip of the Brickyard Peninsula and the Ashby Spit (see map, page vi). He suggests transferring sediment from the Ashby Shoal to the intended beach site. In this study, I attempt to ascertain if the Ashby Shoal can provide the sandy material suitable for this beach-fill project.

In 1981, George A. Armstrong, supervisor of the Beach Erosion Branch of the State Coastal Conservancy, prepared a financial evaluation for construction of a beach at the proposed site. He estimated that the costs for building a 100-foot and a 240-foot wide beach would be about 8.9 million and 13.8 million dollars, respectively (Armstrong, 1981). These estimates, however, are for an elaborate beach with a parking area and costly sand dredged from the bay floor near Angel Island. A financial assessment of bringing in sediment from the Ashby Shoal wasn't considered because Mr. Armstrong believed that "local offshore sand for the proposed project is too fine for beach construction" (Armstrong, 1981, p. 2) and his assumption was verified by the Corps of Engineers. To my knowledge, the Corps of Engineers has not made an in-depth sediment analysis of the Ashby Shoal. In fact, the Corps has been extremely helpful in designing this study and is interested in the results. If the Ashby Shoal can provide the sand for the proposed beach, another cost estimate could be made for the beach project, and it is likely that the reconstruction of the beach would be considerably less expensive.

Site Description

The proposed beach site is located between the Brickyard Peninsula and the Ashby Spit along the Berkeley shoreline (see map, p. vi). The present shore is

composed primarily of very fine to medium-grained sand. Sometimes more than fifty feet of this sand is above the water level at low tide. Riprap is at the top of the shore to prevent erosion of the fill material supporting Interstate 80 and Frontage Road.

The drainage of Strawberry and Potter Creeks (see map, p. vi) may affect the intended beach site. These creeks may carry sediment that could be deposited on the existing shore. Strawberry Creek's outlet is just southwest of the University Avenue and Frontage Road intersection and is north of the proposed beach site. However, it may have an impact on the sedimentation dynamics of the existing shore. Potter Creek flows directly into the beach-fill location. Water from both creeks (that possibly carries sediment from inland erosion) is piped through the fill material under Interstate 80 and the Frontage Road and empties through man-made outlets. Other outlets that possibly transport sediment to the site include a storm-drain and a drainage pipe from Berkeley's Aquatic Park.

The Ashby Shoal is the source of sand in Curt Manning's beach proposal. The shoal is a sand bar about a mile west of the proposed site (see map, page vi). The top of the shoal is above water during many low tides throughout the year.

General Beach Theory

As with any attempt to modify nature, the initial step is to try to understand the process in question and then decide whether this alteration is feasible. "A beach is an accumulation of rock fragments subject to movement by ordinary wave action" (Bascom, 1980, p. 13). It is sensitive to the forces which act upon it--waves, currents, and winds. Sand is always in transit, moving on or offshore or along the beach due to the forces of waves and currents. Beach material is suspended in the surf and is always relocating, except when the wave action is insufficient to resuspend the deposited material (Krone, 1979). Finer sediment is more easily suspended and transported than coarser material (Krone, 1979). Thus, sand tends to be more stable than both silt and clay.

On a stable beach, the forces that bring sand to the shore and those that carry it seaward balance one another. The sediment eroded by rivers, creeks, and other water outlets usually provide most of the new beach material. Some sediment may end up in a cycle, circulating between berms and bars. Berms comprise the flat portion of the beach that is above water. Bars are ridges of sand parallel to the shoreline and are usually found underwater. During periods when high energy waves are prevalent, such as during a storm, sediment tends to flow from the berm to the bar. However, when waves are calm, the sand generally returns

to the berm. Therefore, the berm is generally wider in the calmer summer months than in winter (Bascom, 1980).

A beach system can also receive sediment from a seaward source beyond the bar. Fine sediment may travel great distances before it reaches water that is calm enough for the sediment to settle (Krone, 1979). Level beaches are more likely to receive finer material than steep beaches because waves that dissipate on flat shores tend to have less energy. A beach system can also lose sediment to a seaward sink. This type of erosion could cause a sand bar to lose much sediment. It is difficult to determine if these seaward forces cause more erosion or accretion of a beach system.

Sediment flow along the shore is called littoral transport. Waves usually strike a shoreline at a non-perpendicular angle, favoring one general direction along the coast over the other. As these waves recede, they precipitate sediment which is resuspended by the next wave in the same direction and is deposited farther along. Littoral transport can cause many shoreline problems. Sand can sometimes be removed from a place where it is wanted or desposited to a place where it is not desired, or both (Bascom, 1980). Thus, littoral transport is an important force in sediment dynamics.

Coarser material tends to stabilize on higher parts of the shore than does finer material. Incoming waves usually have more energy than outgoing waves. The incoming waves can gradually move the coarse sediment up the beach. However, the less energetic receding waves can't resuspend the coarser material to carry it back down the shore.

Beach-fill material, once in place, usually behaves similarly to the sediments of the native shoreline site (Hobson, 1977, p. 25) if the material is similar. The fill-material will probably be redistributed across the whole beach in a pattern similar to that of the native sediments. Fill materials coarser than the native sediments are likely to stay put while finer materials will probably be transported from the beach system (Hobson, 1977).

Method

Sediment samples collected from the proposed beach site and the Ashby Shoal provide the basis for evaluating whether the shoal can supply the sandy material suitable for the beach-fill project. The beach site samples were collected in lines perpendicular to the shore approximately a quarter of a mile apart. The first sample of each line was collected at the base of the riprap and the next samples

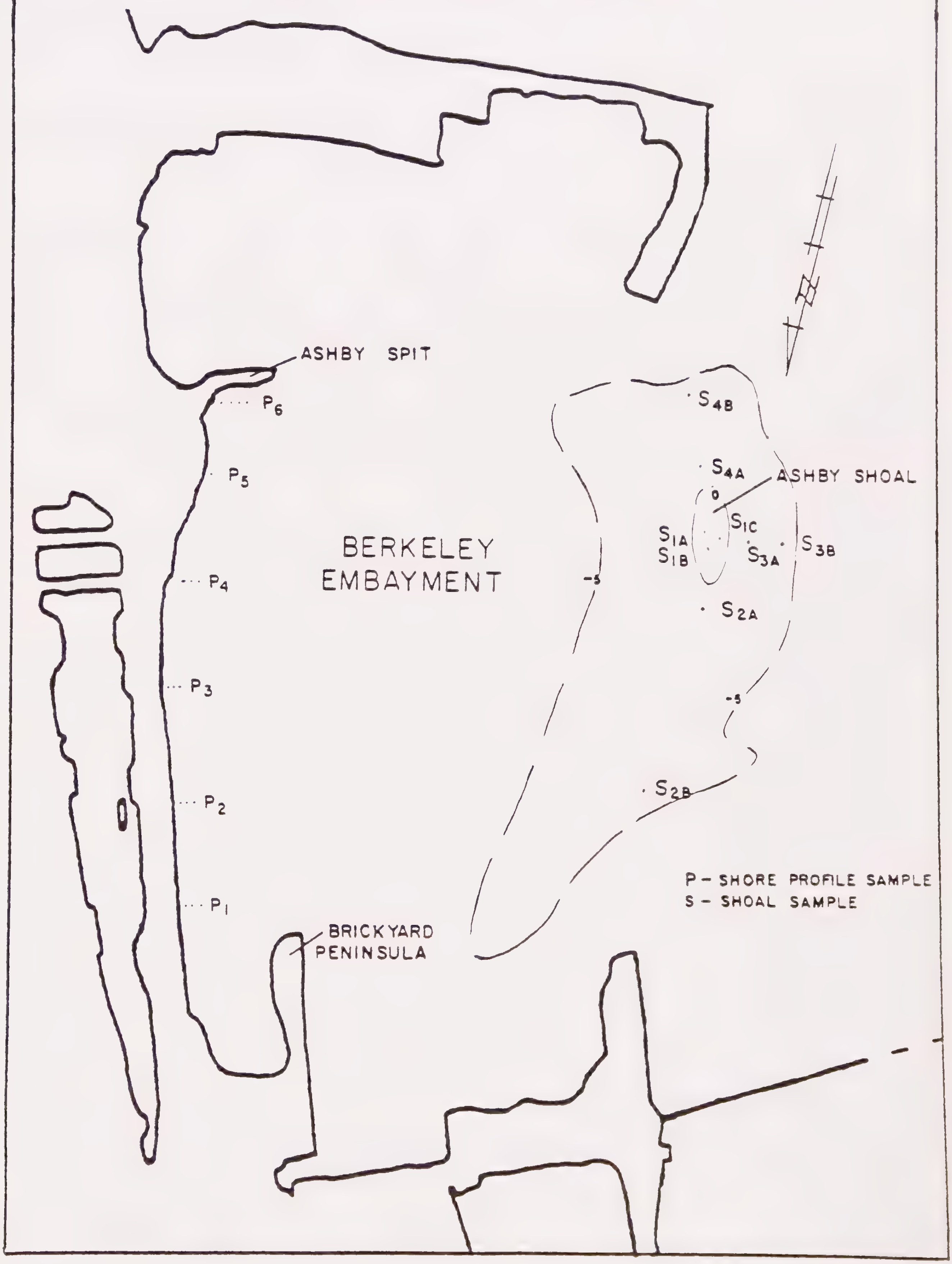
were gathered at roughly fifty foot intervals seaward. Two underwater samples were collected for each line, except line 5. Such lines, called soil profiles, were taken as shown in FIGURE 1. Profiles 1 through 4 were composed of three samples each. Only one sample was taken for profile 5 because the shore drops quickly seaward. Four samples were gathered for profile 6, two samples on the shore and two samples underwater. A sextant was used to read angles between three reference points so that the sample site could be plotted on a topographical map.

Each sample weighed roughly 400 grams and consisted of approximately the top 10 centimeters of the surface sediment. The samples of the shoal and bay floor were gathered from a boat with a grab sampler. The grab sampler employed in this study was composed of a coffee can attached to a ten-foot conduit rod. Some finer sediment mixed in the water of some underwater samples was lost when the sediment was transferred from the grab sampler to the plastic bags used for storing the material. Once the sediment was placed in these storage bags, they were left to air dry.

The grainsize distributions of the soil were determined by sieve analysis and a sedimentation process using a hydrometer modified from ASTM methods (1981) and Griffiths (1967). Due to time constraints, I was forced to combine samples. The samples of each soil profile were mixed and studied as one, leaving one sample for every profile. The shoal samples were combined by mixing the samples that were collected near one another. For instance, the three samples from the top of the shoal were combined to make one sample. After the samples were combined, they were weighted, over-dried and weighed again. Then the samples were wet-sieved on a 230 mesh sieve; the finer material was retained in a pan. The material retained on the sieve was oven-dried and weighed again. If the sediment retained on the sieve weighed more than 90% of the original oven-dried mass, the hydrometer sedimentation analysis was not made, because the information learned from this method could not be used for evaluating the sediment. Calculations were based on the grainsize distributions between the 16th and 84th percentiles by weight. Three samples were studied using the hydrometer method. Almost all of the useful information was gathered through the sieve analysis. A sieve analysis was conducted for every combined sample. The oven-dried material retained on 230 mesh sieve was dry-sieved. A rotation-tapping machine (ro-tap) was used for about twenty minutes on each sample to sort the sand sediment to the appropriate sieve. The material retained on each sieve was weighed and recorded.

FIGURE 1

BERKELEY SHORE PROFILE & ASHBY SHOAL SAMPLE LOCATIONS



Methods of Evaluation

"Review of Design Elements for Beach-fill Evaluation" (Hobson, 1977) was used as a basis for evaluating a beach-fill project. Standards for comparing grain-size distributions of the sediment from the fill source and the existing shoreline are used to predict the stability of a beach partially composed of imported fill material.

Hobson uses a logarithmic transformation (phi) of the Wentworth scale as shown in TABLE 1.

Grainsize (phi)	Grainsize (mm)	Wentworth Classification
-1.5 -1.0	2.83 2.00	Gravel
-0.5 0.0	1.41 1.00	Very coarse sand
0.5 1.0	0.71 0.50	Coarse sand
1.5 2.0	0.35 0.25	Medium sand
2.5 3.0	0.177 0.125	Fine sand
3.5 4.0	0.088 0.062	Very fine sand

TABLE 1. Grainsize (phi) Classifications

In the phi scale, coarser materials have negative values, and finer sediments are positive. The actual parameters utilized in the beach-fill model are the phi mean and phi sorting (phi standard deviation). Phi mean and phi-sorting are calculated from the mass of material that is found between the 16th and 84th percentiles of the cumulative plot. Phi mean is estimated as:

$$\text{Phi Mean} = \frac{phi_{84} + phi_{16}}{2}$$

Phi sorting is calculated as:

$$\text{Phi Sorting} = \frac{phi_{84} - phi_{16}}{2}$$

The 16th and 84th percentiles are used because the material between these two end points is more representative of the surrounding beach area than if all of the stray sediments in the whole sample were included.

The adjusted Shore Protection Manual (S.P.M.) method is generally recommended as the best approach for beach-fill evaluation (Hobson, 1977). An average value for phi mean and phi sorting is calculated for both the existing shore and the fill source. These averages are computed from the sum of the percentages of each size classification and then are divided by the number of samples that were added. Once the averages for the grainsize classifications are determined, the phi mean and phi sorting for the shore and fill material source can be calculated in the previously discussed method. The adjusted S.P.M. method roughly states that if the phi mean and phi sorting of the fill sediment is less than or equal to the phi mean and phi sorting of the material of the existing shore, then the proposed beach-fill would probably be stable. To clarify, a stable beach can be constructed if the fill material is coarser and has a smaller standard deviation than the shore sediment. For a more complete technical explanation, read Hobson's paper.

Data

Both the proposed beach site and the shoal consist primarily of medium and fine-grained sand as shown in TABLE 2.

Sample Location	Very Coarse Sand	Coarse Sand	Medium Sand	Fine Sand	Very Fine Sand	Silt and Clay
Profile 1	1.1	2.3	44.0	50.0	2.5	0.0
Profile 2	2.4	2.2	41.8	49.4	4.1	0.1
Profile 3	5.9	1.6	9.4	56.6	21.9	4.6
Profile 4	2.0	1.1	23.2	43.3	23.6	6.8
Profile 5	8.6	5.7	35.0	35.7	12.6	2.4
Profile 6	8.3	4.0	17.6	39.7	29.1	1.3
Profile Average	4.7	2.8	28.5	45.8	15.6	2.6
Shoal 1	1.2	0.8	21.9	74.6	1.3	0.2
Shoal 2	5.0	5.7	19.7	46.5	14.2	8.9
Shoal 3	0.5	2.1	21.4	54.6	19.4	2.0
Shoal 4	0.4	1.2	42.4	47.8	7.2	1.4
Shoal Average	1.7	2.5	26.4	55.9	10.5	3.0

TABLE 2. Grainsize Distributions of Samples in Percent (According to the Udden-Wentworth Scale).

The proposed beach site tended to have coarser sediment on its northern and southern edges (profiles 1, 2, 5, 6) than in its center (profiles 3, 4). This relationship is illustrated by the phi means of the six profiles in TABLE 3.

Profile Samples	P_1	P_2	P_3	P_4	P_5	P_6	$P_{Average}$
Phi Mean	2.1	2.1	2.7	2.7	2.1	2.3	2.4
Phi Sorting	0.5	0.6	0.6	1.0	0.9	0.9	0.8

Shoal Samples	S_1	S_2	S_3	S_4	$S_{Average}$
Phi Mean	2.4	2.4	2.5	2.1	2.3
Phi Sorting	0.5	0.9	0.7	0.5	0.6

TABLE 3. Phi Mean and Phi Sorting of the Shore Profiles and Shoal Samples

The phi mean of the average shore profile is 2.4 and the phi mean of the average shoal sample is 2.3. Thus, the shoal has slightly less fine sediment than the shore. The shoal material has a smaller phi sorting (standard deviation) than the shore (see TABLE 3). Therefore, the shoal sediment is more consistent than the material collected from the profiles along the shore.

Two observations (not quantified in the lab) of sediment dynamics were made along the beach. The first observation was that the sediment gathered between the shoal and the shore was much finer than the material of both the shoal and the shore. The other visual observation was made while gathering the shore profile samples. The sediment higher on the beach tended to be coarser than the material on the lower parts of the shore.

Conclusion

Predicting the stability of a beach-fill at a shoreline site is an extremely complex task. The quantitative analysis given by Hobson in evaluating beach-fill longevity is simplistic; however, it is the best approach to date.

Hobson indicates that a stable beach can be formed when the sediment of the source is coarser and has a smaller standard deviation than the beach-site material. This relationship occurs between the shoal and the shore. Thus, on the basis of this method, I believe that a stable beach can be formed from the Ashby Shoal material. However, more research should be done. Core samples should be taken at

the shoal to determine what type of sediment is beneath the surface of the shoal. Also, a study should be made of the impact of reducing the shoal on the shoreline erosion processes.

REFERENCES CITED

American Society for Testing and Materials, 1981. 1981 Annual Book of ASTM Standards. Part 19 Natural Building Stones, Soil and Rock: Easton, MD, American Society for Testing and Materials, pp. 113-123.

Armstrong, George A., November 18, 1981. Berkeley Beach Restoration Project, Alameda County: Sacramento, CA, Department of Boating and Waterways, pp. 1, 2.

Bascom, Willard, 1980. Waves and Beaches: Garden City, New York, Anchor Books, Anchor Press/Doubleday, 366 pp.

Domurat, George, Oceanographer, U.S. Army Corps of Engineers. Personal communication, April 2, 1982.

Griffiths, John C., 1967. Scientific Method in Analysis of Sediments: New York, NY, McGraw-Hill, 508 pp.

Hobson, R.D., June 1977. Review of Design Elements for Beach-Fill Evaluation. Fort Belvoir, VA, Coastal Engineering Research Center, 50 pp.

Houston, W.N., Professor of Civil Engineering, U.C. Berkeley. Personal communication, April 28, 1982.

Krone, R.B., 1979. Sedimentation in the San Francisco Bay System, T.J. Conomos, ed., in San Francisco Bay: The Urbanized Estuary, Pacific Division, Amer. Assoc. Advanc. Sci., San Francisco, CA.

Lesnik, John R., Hydraulic and Coastal Engineer, G.A.I. Consultants, Inc., personal communication, April 2, 1982.

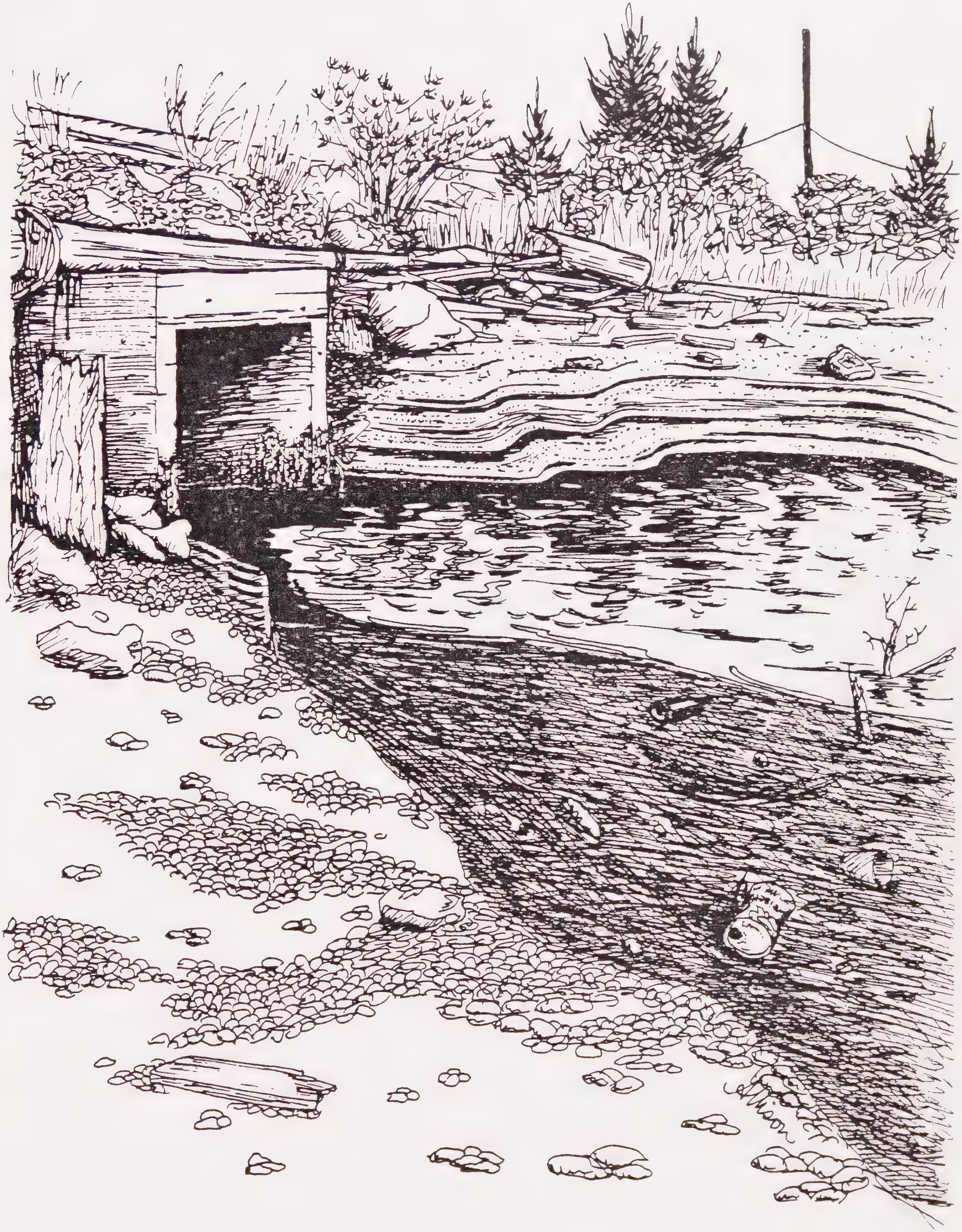
Manning, Curt, Chairman, Berkeley Beach Committee, personal communication, February 17, 1982.

Pirie, Douglas, Coastal Engineer, U.S. Army Corps of Engineers, personal communication, April 2, 1982.

Sustar, John, Coastal Engineer, U.S. Army Corps of Engineers, personal communication, March 2, 1982.

Wiegel, R.L., Professor of Hydraulic and Coastal Engineering, U.C. Berkeley, personal Communication, April 26, 1982.

SECTION III: WATER QUALITY STUDIES



Chapter 1

WATER QUALITY MANAGEMENT ALONG THE EAST BAY SHORELINE AREA

Aaron E. Jeung

In 1892 an outbreak of cholera in the city of Hamburg, Germany killed thousands of people in that community. The River Elbe, which directly supplied the city with its drinking water, was contaminated with the bacteria Vibrio cholorae. After some investigation, the source of this waterborne disease was discovered. It seems a small band of Russian immigrants had set up camp a few miles up-river from Hamburg and were dumping their cholera-laced raw waste directly into the River Elbe. This small amount of raw waste had polluted the river water and made it unsuitable for human consumption. Needless to say, the immigrants were forced to move (Gan, 1982).

At the same time in Altona, Germany, a neighboring city comparable in size and population to Hamburg, 90% fewer people died from cholera. The Altona water supply also originated from the River Elbe, but, before the water reached the residents of Altona, it was treated in a slow-sand filter system. The system, which was installed a few years prior to the cholera outbreak, prevented thousands of deaths and illnesses (Gan, 1982).

Water: we drink it, flush it, channel it, dam it, and even squirt it. Life without it would not only be dry and stagnant but quite impossible as well. Nonetheless, we have found numerous ways to waste it, pollute it, and generally ruin it for ourselves and all other living beings with which we share it. There is just so much of it around, that it is often taken for granted. This general disregard for water is reflected in the notion that, "Dilution is the solution to pollution." We in our own self-destructive way, have rationalized that we can dump anything we want to discard into the nearest sewer, creek, or bay, and the refuse will be washed out to sea, never to be seen or heard of again. The tragic Hamburg story is an example of how wrong this philosophy can be. A small amount of pollution can ruin water quality for certain uses. We must not just use our water, but we must

manage it as well.

The Hamburg-Altona story not only presents the consequences of ignoring water quality, but it also illustrates that we can manage it. In order for us to manage water quality along the East Bay shoreline effectively, we must perform six major tasks. The tasks are as follows: (1) describe the physical characteristics of the shoreline waters; (2) determine the potential beneficial uses of the shoreline water; (3) define the possible water quality problems; (4) provide water quality objectives to solve these problems; (5) identify the sources of these problems; (6) implement plans that will solve present problems and prevent future ones.

In this overview for the following chapters which will focus on water quality along the East Bay shoreline, these six tasks will be discussed, first generally for the East Bay shoreline, then specifically for a single beneficial use. It is hoped that this background information will allow the reader to understand the importance as well as some of the details of water quality management.

Physical Characteristics of the Bay

San Francisco Bay is a single, complex, and interrelated estaurine system. The bay waters are a mixture of ocean and inland waters. The saline ocean waters enter the bay through the Golden Gate, and the fresh inland waters originate mainly from the Sacramento River. Other sources of fresh water include flows from sewage outfalls, creeks, streams, and small rivers. The Sacramento River water water is largely responsible for flushing the bay of pollutants. Even though this flushing action is of great importance, the tidal changes and the resulting circulatory patterns also play a major role in the removal and distribution of contaminants from the bay. Because these circulation patterns are complicated and not well understood, those patterns which directly affect the East Bay shoreline waters should be studied (see papers by Peter Gee and Linda Goad). The area under discussion stretches from Pt. Isabel to the San Francisco Bay bridge toll plaza and extends from the shoreline to the mean lower low tide line.

Potential Beneficial Uses

By taking into account the bay's various physical characteristics, the California Regional Water Quality Control Board has identified potential beneficial uses for the shoreline waters. These potential uses need to be identified in order for proper water quality objectives to be formulated, thereby insuring the continuance of these uses. The beneficial uses appropriate for the East Bay shoreline are listed below (FWQCB, 1975, pp. 14-16):

Water Contact Recreation - includes all recreational uses involving actual body contact with water where ingestion of water is possible.

Non-contact Water Recreation - recreational uses that involve the presence of water but do not require contact with water.

Ocean Commercial Sport Fishing - the commercial collection of various types of fish and shellfish, including those taken for bait purposes, and sport fishing in oceans, bays, estuaries, and similar non-freshwater areas.

Wildlife Habitat - provides an aquatic habitat for the maintenance of wildlife.

Preservation of Rare and Endangered Species - provides an aquatic habitat necessary, at least in part, for the survival of certain species established as being rare and endangered species.

Marine Habitat - provides for the preservation of the marine ecosystem including the propagation and sustenance of most forms of aquatic life.

Shellfish Harvesting - the collection of shellfish such as clams, oysters, abalone, shrimp, crab, and lobster for either commercial or sport purposes.

Water Quality Problems

Each of these potential beneficial uses of the East Bay shoreline waters depends on specific water quality characteristics. Water quality satisfactory for one use may not be "clean" enough for another. As a result, the term "polluted" has little value in describing the water quality along the shoreline. The best way to illustrate the shoreline's water quality problems is through the use of pollution indicators. Each indicator represents a specific physical, chemical, or biological characteristic used to measure environmental distress or damage in shoreline waters. The indicators are as follows:

Dissolved Oxygen - the amount of oxygen dissolved in the water. An adequate level of dissolved oxygen is necessary for protection of aquatic life. A reduction of dissolved oxygen levels leads to a decrease in aquatic populations. Reduced levels indicate

the discharge of excessive organic matter into receiving waters.

<u>Floatable Materials</u> - consist of any substance or object that will float on the surface of the water. The most prevalent examples of these materials are oil and grease. They may be derived from many sources, including industrial waste water, storm sewer discharge, and overflows of sewage treatment plants. They are most objectionable when they are foreign to their surroundings.

<u>Coliform Bacteria</u> - are indicator organisms selected for measuring the safety of waters for recreational uses. The coliform bacteria show the presence of human and animal wastes in the water. High coliform levels may indicate the presence of other pollutants. The test for coliforms is used quite extensively because it is relatively simple and inexpensive.

<u>Biostimulants</u> - a term used to encompass all of the nutrient material that may be discharged to a receiving water. Nutrients are principally nitrates and phosphates. High concentrations of these biostimulants cause enrichment, which stimulates the excessive growth of algae. These growths result in unsightly scum, discoloration, odors, and severe decreases in dissolved oxygen levels.

<u>Toxicity</u> - a comprehensive measure of poisonous characteristics of wastewater. High concentrations of toxic materials can bring about adverse effects on existing aquatic life.

<u>pH</u> - a term used to express the intensity of the acid or alkaline condition of a solution. It is important in many biological processes and must be maintained within a range favorable to aquatic organisms.

<u>Pesticides</u> - chemical compounds used for the control of troublesome insects, plants, or animals. Many pesticides, such as the chlorinated hydrocarbons, break down very slowly and can accumulate in plant and animal tissue, ultimately killing them.

Water Quality Objectives

Objectives for these water quality parameters must be set in order to solve the problems. The objectives adopted by the Regional Water Quality Control Board for the aforementioned pollution indicators are as follows:

-- Dissolved oxygen: Minimum of 5 mg/1.

-- Floatable materials: None other than of natural causes.

-- Coliform bacteria: Maximum of 1,000 MPN/100 ml.

-- Biostimulants: Shall not contain these substances in amounts that will produce nuisance conditions which adversely affect potential beneficial uses.

-- Toxicity: None at levels which render aquatic life unfit for human consumption.

-- pH: Not to be depressed below 6.5 or raised above 8.5.

-- Pesticides: None present in concentrations that adversely affect beneficial uses; no increase in concentrations found in bottom sediments or aquatic life.

Sources of Pollution

The water quality of any body of water is determined by a complex set of factors; the many processes of nature are augumented by the activities of man. Because there is no single source for pollution, there is no single measure of pollution. Pollution sources are divided into two broad categories: point sources and non-point sources.

Municipal and industrial wastes which have been treated by man-made processes, then discharged into a body of water, are considered to have originated from a point source. The other sources of pollution are called non-point sources. These sources are not treated by man-made processes before being discharged into a body of water. Wasteloads from non-point sources originate at agricultural operations, construction sites, urban runoff vessel wastes, oil spills and dredging spoils.

The major pollution sources along the East Bay shoreline are non-point sources. Non-point sources located along the shoreline include the various storm drains, sewer outfalls, creeks, dumps and boats, as well as "accidental" midnight discharges by industry. Other sources are the Berkeley Marina, Golden Gate Fields, and an occasional oil spill.

Solutions

General solutions to point source pollution problems include: the use of advanced treatment, the use of dilution-assimilation capabilities of certain

bodies of water, the local treatment of wastes, consolidation of local treatment systems to process wastes, and reclamation/reuse of the water resource (RWQCB, 1975). Each of these solutions has definite advantages and disadvantages. For the East Bay, facilities for treatment to the full secondary level with an outfall just south of the San Francisco Bay Bridge have been constructed to meet and maintain water quality objectives for the shoreline area.

Thus far, much of the effort for water quality control has been concentrated upon point source control. Soon this effort will reach a point where the monetary investment will not produce adequate returns. The treatment of water to a tertiary level is very costly and does not solve the remaining pollution problems (e.g., hazardous wastes) (Sharpe, 1977). A more cost-effective method of dealing with these problems would be to address non-point source pollution problems. Implementing measures such as street sweeping to reduce the availability of pollutants for washout during storms, monitoring storm drains and sewer outfalls on a regular basis, and more pretreatment of industrial wastes would help to reduce some of the remaining pollution levels.

Implementation

To illustrate that solutions to water quality problems can be effective, the discussion will focus upon the beneficial use of water contact recreation. Water contact implies the risk of waterborne disease transmission and involves human safety. Accordingly, criteria required to protect this use have been established. The following standards apply to waters used for water contact recreation (California Department of Public Health, 1958, pp. 2-3):

> Physical Standard: No sewage sludge or grease or other evidence of sewage discharge shall be visible on any public beach or water contact sports area.
>
> Biological Standard: Most probable number (MPN) of coliform organisms shall not be greater than 1,000 MPN per 100 ml.

A 1963-64 study found that coliform levels along the East Bay shoreline did not meet the above water quality objectives (Pearson, 1965). A 1969 study of the bay states, "Areas along the Berkeley shoreline have long been plagued with odor problems . . . " (Wu, 1969, p. 14). The source of the odor was traced to a waste discharge at Gilman Street which used to receive industrial wastes from three industrial plants in Berkeley (Wu, 1969).

To solve these problems, the East Bay Municipal Utility District up-graded treatment of municpal and industrial wastewater before discharging it into the bay.

Presently, most of the shoreline waters are safe for water contact use, and there have been no reports of odors originating from the water column (Young, 1982). Other data have been collected and summarized (TABLE 1) and will be presented in the following paragraphs.

TABLE 1 summarizes bacteriological tests taken along the East Bay shoreline. The site locations are shown in FIGURE 1.

TABLE 2 shows that there are elevated bacteriological counts all along the shoreline. Only one site, site 5, had an average total coliform count of less than 1,000 MPN. Site 5 is located at the mouth of Berkeley's Marina and is not part of the "immediate" shoreline (see FIGURE 1). All the other sites are located directly on the shoreline and are either at or near a sewage outfall. The two sites with the highest counts, site 2 and site 11, are located at almost opposite ends of the study area. This indicates that there is not just one general area along the shoreline that is more "polluted" than the others, but that there are pollution problems all along the shore. These two sites have at least 100,000 MPN higher counts than any other site. Site 2 is found quite near Golden Gate Fields. Possibly the animal wastesor human wastes cause these high counts. Site 11 is close to many of Berkeley's industries, but there is no conclusive evidence that these industries are the cause of the high coliform counts. Sites 3, 4, 6, and 13 have fairly high coliform counts (greater than 10,000 MPN). These sites are located at storm drain outfalls that deposit surface runoff materials from the streets into the bay. The remaining sites, 1, 7, 8, 9, 10, and 12 have fairly low coliform counts (less than 10,000 but greater than 1,000 MPN). These sites are located various distances away from sewer outfalls. A comparison of coliform level from these sites with those of nearby sewer outfall sites, shows that high coliform levels can be reduced by as much as a factor of ten over relatively short distances. Tidal action, dilution capabilities and the salinity of the shoreline waters make them safe for water contact recreation.

TABLE 3 summarizes the average monthly total coliform levels from sites 7, 8, 9 and 10. This table shows that during the three years these sites were monitored, coliform levels were lowest during the winter months of November and December. The months of March, May and June also showed fairly low levels. Even though the coliform levels are low during these months, all the counts are still above the water quality objectives for contact recreation (RWQCB, 1975). The highest levels are found in July during the dry summer months. "Monitoring studies indicate that bacterial pollution of the shoreline probably results from municipal sewage discharge

1965

Month/Source[b]		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
		A	A	A	A	A	A	A	A	A	A	A	A
Site[a]	7	7,000	2,400	2,400	620	620	-	7,000	7,000	2,400	7,000	7,000	60
	8	2,400	2,100	2,400	2,400	7,000	-	2,400	7,000	2,400	230	2,300	60
	9	620	620	2,400	2,400	500	-	500	620	2,300	60	2,300	230
	10	2,400	2,400	7,000	2,400	620	-	130	1,300	2,400	7,000	620	7,000

1970

Source[b]		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
					D								
Site[a]	1				620								
	2				62,000								

1973

Source[b]		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
		A	A	A	A	A	A	A	A	A	A	A	A
Site[a]	7	11,000	430	430	930	40	1,500	2,400	90	4,600	4,600	230	2,900
	8	2,400	290	230	930	90	4,600	11,000	930	4,600	24,000+	930	7,500
	9	2,400	2,400	2,400	930	90	2,100	2,400	4,600	2,400	11,000	230	430
	10	4,600	930	4,600	11,000	24,000+	4,600	24,000+	24,000+	11,000	24,000+	40	2,100

1974

Source[b]		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
		A	A	A	A	A	A	A	A	A	A	A	A
Site[a]	7	750	11,000	1,500	24,000+	230	930	24,000+	2,400	1,500	930	4,600	460
	8	2,400	11,000	1,500	24,000+	430	430	24,000+	11,000	4,600	930	930	430
	9	4,600	460	2,400	24,000+	2,400	390	24,000+	440	24,000+	430	2,400	1,500
	10	930	24,000+	1,500	24,000+	30	4,600	24,000+	24,000+	24,000+	430	2,400	1,500

1976

Source[b]		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
		B	B	B	B	B	B	B	B	B	B	B	B
Site[a]	1	910	300	9,300	360	300	300	300	300	300	300	2.2	-
	2	9,300	9,300	24,000	360	360	2,300	9,300	2,300	2,300	2,300	110,000	-
	3	300	4,300	240,000+	24,000	24,000	110,000	46,000	9,300	9,300	24,000	110,000	-
	4	4,300	7,500	240,000+	300	300	110,000	240,000+	46,000	46,000	240,000+	240,000+	-
	6	110,000	24,000	240,000+	24,000	240,000+	240,000+	110,000	240,000+	240,000+	24,000	110,000	-
	11	240,000+	240,000+	240,000+	240,000	240,000+	24,000+	46,000	46,000	240,000+	240,000+	240,000+	-
	12	2,300	910	15,000	910	7,500	360	910	910	360	24,000	24,000	-
	13	240,000+	300	24,000	360	1,500	300	360	360	240,000+	300	2.2	-

1977

Source[b]		C	C	C	C	C	
Site[a]	1	930	–	9,300	9,300	43,000	- - - no dry weather samples taken - - -
	2	24×10^5	24×10^5	24×10^5	24×10^5	24×10^5	- - - no dry weather samples taken - - -
	3	110,000	120,000	–	–	–	- - - no dry weather samples taken - - -
	4	9,300	9,300	2,300	9,300	44,000	- - - no dry weather samples taken - - -
	5	–	90	–	–	–	- - - no dry weather samples taken - - -
	6	43,000	93,000	–	–	–	- - - no dry weather samples taken - - -
	11	240,000	–	460,000	–	–	- - - no dry weather samples taken - - -
	12	43,000	–	–	–	–	- - - no dry weather samples taken - - -
	13	9,300	–	43,000	–	–	- - - no dry weather samples taken - - -

1979

Source[b]		E					F	F	F		F	F	F
Site[a]	1	1,100 (average of 37 tests taken in 1979)											
	2	3,000 (average of 34 tests taken in 1979)											
	5	–	–	–	–	–	40	16	70	–	130	2,400	3,500

1980

Source[b]		F	F	F	F	F	F	F		
Site[a]	5	1,300	1,300	490	2,400	490	13	230	–	--study ended in July--

(a) Site
1 Cerrito Creek mouth
2 Buchanan Street outfall
3 Gilman Street outfall
4 Virginia Street outfall
5 Berkeley Marina ocean entrance
6 University Avenue/Strawberry Creek outfall
7 1500 feet south of University Avenue
8 3000 feet south of University Avenue
9 4500 feet south of University Avenue
10 6000 feet south of University Avenue
11 Potter Street outfall
12 65th Street
13 Powell Street outfall

(b) Source
A EBMUD Shoreline Monitoring Program (Sharpe, 1977)
B EBMUD Shoreline Sampling Results (Sharpe, 1977)
C EBMUD Wet Weather and Storm Sewer Study (Sharpe, 1977)
D State Health Department Study of Water Quality Near Albany Hill (RWQCB, 1977)
E SFRWQCB San Francisco Bay Shellfish Program (RWQCB, 1981)
F Berkeley Department of Public Health Study of Water Quality at the Berkeley Marina Basin (Gerber, 1980)

TABLE 1. East Bay Shoreline Summary Total Coliform – MPN/100 ml.

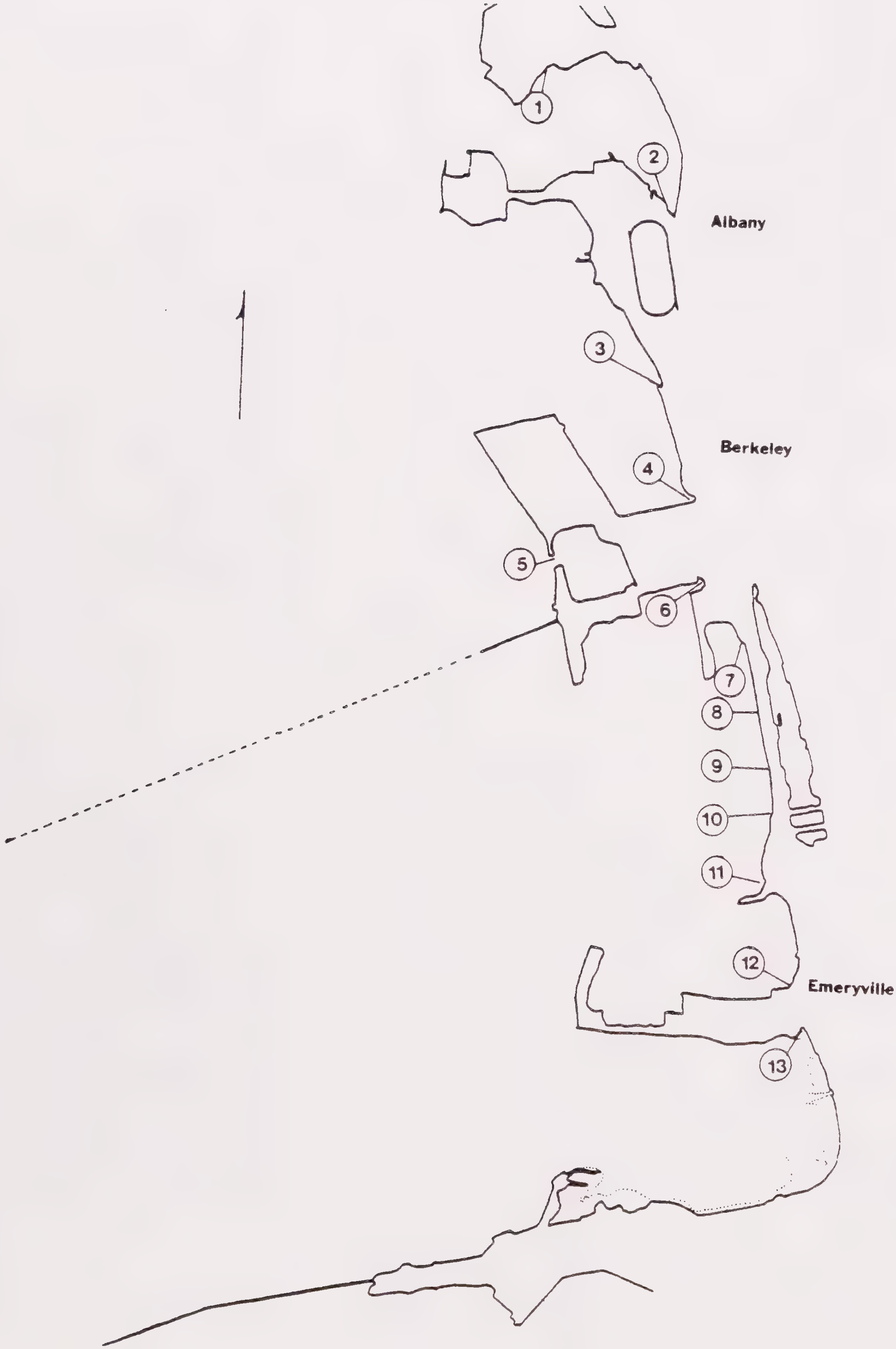


FIGURE 1: East Bay Shoreline - Location of Total Coliform Test Sites.
Base Map: USGS Topographic Map, Oakland West & Richmond Quadrangle, Sharpe, 1977.

Site	Average Coliform Count	Rank*	# of Tests Performed
1	2,200	2	54
2	240,000	13	51
3	130,000	11	13
4	76,000	9	16
5	665	1	14
6	125,000	10	13
7	4,200	4	35
8	4,600	5	35
9	3,800	3	35
10	7,800	6	35
11	220,000	12	13
12	9,000	7	12
13	24,000	8	13

*Ranking of average coliform counts

TABLE 2. East Bay Shoreline Summary Total Coliform Site Averages - MPN/100 ml.

Month	Average MPN/100 ml	Rank*	# Tests
January	3,500	6	12
February	4,800	7	12
March	2,400	3	12
April	9,600	11	12
May	3,000	5	12
June	2,400	4	8
July	24,000	12	12
August	7,000	8	12
September	7,200	10	12
October	7,000	9	12
November	18,000	1	12
December	2,000	2	12

*Ranking of monthly coliform counts

TABLE 3. Summary of Total Coliform Tests from Sites 7, 8, 9, 10 Taken in 1965, 1973, 1974 - Monthly Averages.

during dry weather" (Sharpe, 1977, p. 49). Also, power outages which usually occur during hot summer days may cause shut-downs of sewage treatment plants, causing the sewage to flow directly into the bay. The next highest counts were found in April. This was probably caused by " . . . surface runoff and combined sewer overflows during dry weather" (Sharpe, 1977, p. 49). Therefore, the best time for the use of shoreline waters is in the wintertime and not in the summer when water contact sports are most popular.

TABLE 4 summarizes the yearly total coliform averages from the thirteen sites along the shoreline. A comparison of the coliform levels from year to year at

Site	1965	1970	1973	1974	1976	1977	1979	1980
1		620			1,100	16,000	1,100	
2		62,000			16,000	24×10^5+	3,000	
3					50,000	610,000		
4					100,000	19,000		
5						90	500	890
6					134,000	68,000		
7	4,000		2,500	6,100				
8	2,800		1,700	9,300				
9	1,100		2,700	7,400				
10	3,000		11,000	9,000				
11					200,000	350,000		
12					6,400	43,000		
13					24,000	26,000		

TABLE 4. East Bay Shoreline Total Coliform Test Summary Yearly Average at Each Site.

separate sites does not show any prevailing trends. There have not been enough tests taken over a long enough period of time for any trends to be discovered. More testing and constant monitoring are needed to make predictions about yearly trends. If there is a monitoring program, bacterial contamination from non-point sources along the shoreline can be predicted and then controlled. Until the present, there has been no pressing need to implement this kind of monitoring program. If there is to be any type of water contact recreation area developed along the shoreline (e.g., Berkeley Beach), a program must be started.

Conclusion

We can manage our water quality. We have been able to eliminate the problems of gross pollution by the clean-up of municipal and industrial sewage. "Now most of the bay is safe for swimming, except after periods of storm runoff" (ABAG, 1977, p. 8). Nonetheless, not all water quality problems have been eliminated from the East Bay shoreline area. As shown in TABLE 1, there is still contaminated water pouring out of all the various storm drains along the shore. This contaminated water has so polluted the shoreline waters that the shellfish harvesting water quality objective may never be met (see paper by Mirtha Ninayahuar). Deadly hazardous wastes threaten to destroy water quality at various shoreline locations (see paper by John Cruz). Much work still needs to be done, but with the cooperation of state and local agencies, and the input of an educated public, these problems can and will be solved. When these problems are solved, the East Bay shoreline can be fully enjoyed by generations to come.

REFERENCES CITED

Association of Bay Area Governments, 1977. Environmental Management Plan, Berkeley, California, 85 pp.

California Department of Public Health, 1958. "Laws and Regulations Relating to Ocean Water Contact Sports Areas: excerpts from the California Health and Safety Code, Berkeley, California, 5 pp.

California Regional Water Quality Control Board, 1981. Bacteriological Survey of San Francisco Bay, 48 pp.

__________, 1981. San Francisco Bay Shellfish Program, California, 285 pp.

Gan, David, Public Health Chemist, State Department of Health Services, personal communication, 1982.

Gerber, Martin J., 1980. A Study of Water Quality at the Berkeley Marina Basin, Berkeley Department of Public Health, 30 pp.

Metcalf & Eddy, Inc., 1971. Storm Water Problems and Control in Sanitary Sewers: Berkeley and Oakland, California, U.S. Environmental Protection Agency, 290 pp.

Pearson, E.A., 1965. A Comprehensive Study of San Francisco Bay, 1963-64, North Central San Francisco Bay Area's fourth annual report, SERL Report #65-1, University of California, Berkeley, 14 pp.

Samaniego, Robert, Water Resources Control Engineer, California Regional Water Quality Control Board, personal communication, 1982.

San Francisco Bay REgional Water Quality Control Board, 1975. "Water Quality Control Plan, San Francisco Bay Basin," Abstract, State Water Resources Control Board, 61 pp.

(continued)

Sharpe, Clifford A., 1977. An Analysis of the Factors Affecting the Possible Establishment of a Commercial Shellfish Operation in San Francisco Bay Along the Berkeley Shoreline. California State Health Department, 52 pp.

Wu, Teng-chung, 1969. Water Quality Problems in San Francisco Bay, California Regional Water Quality Control Board, 25 pp.

Young, Clarence, Chief Sanitary Engineer, State Department of Health Services, Berkeley. Personal communication, 1982.

Chapter 2

THE POTENTIAL FOR RECREATIONAL SHELLFISH HARVESTING ALONG THE BRICKYARD SHORELINE

Mirtha Ninayahuar

The State Department of Parks and Recreation presently regards the Berkeley Brickyard (FIGURE 1) as a prime site for the first phase of a proposed East Bay Shoreline Park. The purpose of this report is to examine the potential for safe recreational shellfish harvesting in this area with respect to the following points: (1) the suitability of shellfish resources for recreational harvesting; (2) the levels of major contaminants in the shellfish; (3) the public health standards affecting the possible establishment of recreational shellfish harvesting. Two shellfish beds exist along the Brickyard shoreline, one at the end of Bancroft Way (FIGURE 1, bed #15) and the other at the end of University Avenue (bed #16). In an attempt to determine the possibility of recreational harvesting in this area, I will review and summarize shellfish studies dating from 1970 to 1981 performed in or around the Brickyard area, and present results of tests conducted for this study.

Species of shellfish studied are those most abundant and popular with recreational harvesters of the San Francisco Bay. These include the Japanese littleneck clam (*Tapes japonica*), the softshell clam (*Mya arenaria*), and the bay mussel (*Mytilus edulis*). Consideration is given to the following contaminants: bacteria, viruses, paralytic shellfish poison, trace metals, and synthetic organic compounds (i.e., pesticides). The quality of water overlying the shellfish beds will be touched upon only briefly, as Aaron Jeung's report entitled "Water Quality Management Along the East Bay Shoreline Area" evaluates the water quality around the Brickyard.

Introduction

Just before the turn of the century San Francisco Bay was a rich source of shellfish for commercial and recreational harvesters. The bay supplied most of California's shellfish used in trade (RWQCB, 1978). Up to 15 million pounds of oysters were harvested from the bay each year (Vandre, 1980). Pollution after the

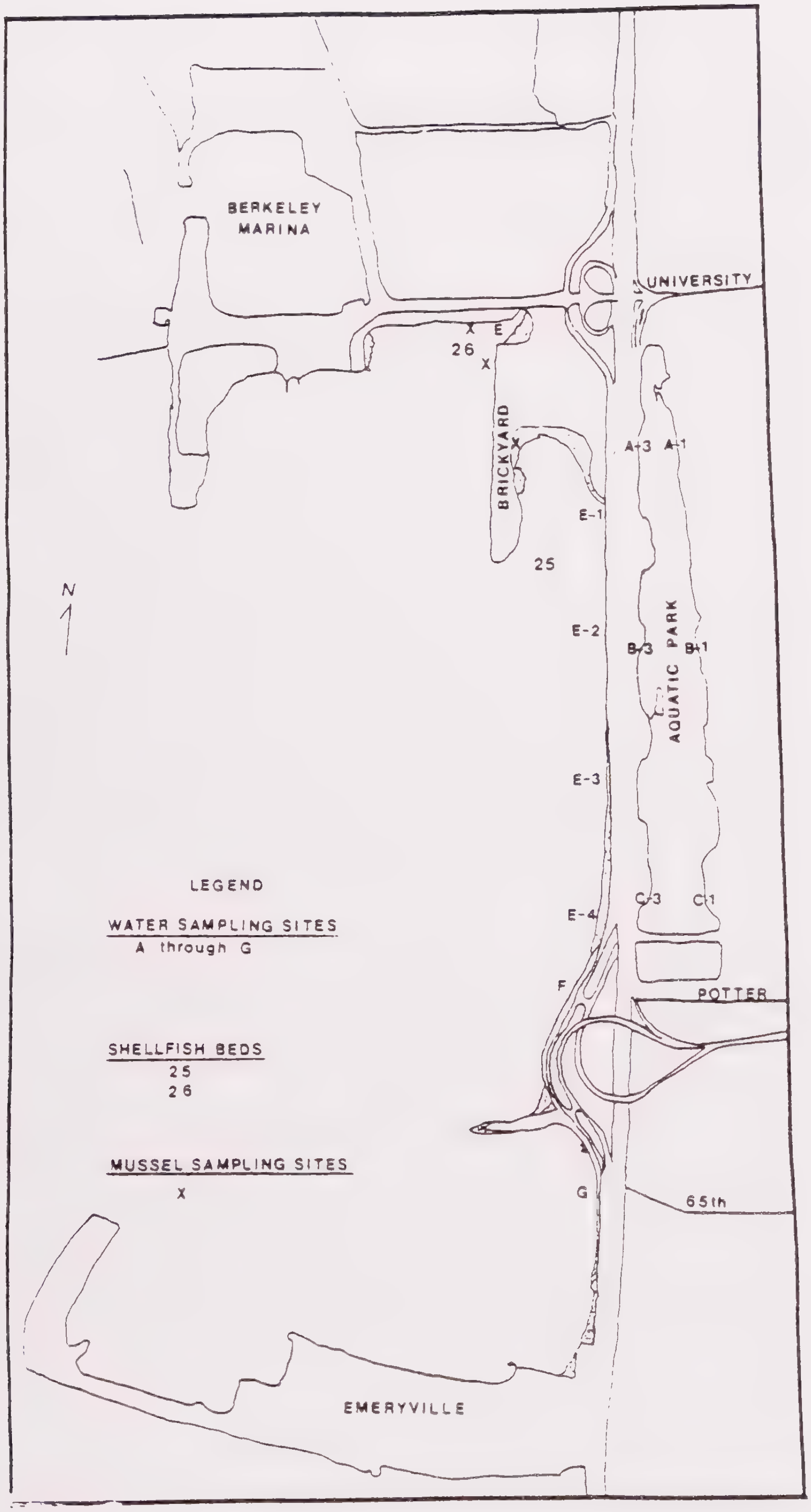


FIGURE 1. Sampling Site Locations.

Source: Water Sampling Sites, Sharpe, 1977.
Shellfish Bed Locations, Jones and Stokes, 1977.
Base Map, USGS Topographic Map: Richmond, 1968; Oakland West, 1973.

1900's caused the ultimate closure of all commercial shellfish operations, as well as the sharp decline of recreational harvesting. California presently has an annual mussel quarantine between May 1 and October 31 which prohibits the harvesting of all mussel species along the coast and in all bays, inlets, and harbors (Jones and Stokes, 1977). Aside from this, recreational harvesting is legal; however, it is not recommended by state and county health agencies. Certain shellfish beds have been posted as being unsafe due to high levels of contaminants, but these postings are only warnings and are not enforced to prevent recreational harvesting. Currently limited and uncontrolled recreational harvesting occurs in the bay without any assurance as to the quality of shellfish harvested (RWQCB, 1978). In a 1981 survey for the East Bay Municipal Utility District, sections along the Brickyard shoreline were rated as areas being moderately exploited for shellfish, while areas nearby, such as the south end of the Berkeley Marina, were rated as being heavily exploited (Sutton, 1981). Of all the shellfish collectors along the East Bay shoreline that were interviewed in Sutton's study, more than half indicated that they used the shellfish for food.

The restoration of safe shellfish harvesting depends largely on the efforts to clean up the bay. Since 1974 approximately $,750,000 has been committed for wastewater treatment specifically to protect shellfish (RWQCB, 1978). Portions of these funds have been used for adding advanced secondary treatment facilities to wastewater treatment plants, as well as for extending outfalls farther away from shellfish beds (Jarvis, pers. comm., 1982).

In 1978, the Regional Water Quality Control Board (RWQCB, San Francisco Bay Region) adopted a resolution (No. 78-8) to achieve the opening of San Francisco Bay shellfish beds for recreational use. The goal of the RWQCB Shellfish Program includes determining the factors and conditions that may affect the safety of an area for direct recreational harvesting, what periodic monitoring would be needed to detect adverse changes in water quality and shellfish safety, and what additional control of point and nonpoint sources of contamination can be accomplished to minimize closing of an area. The Regional Board is coordinating the Shellfish Program with the help of the State Department of Health Services, the Department of Fish and Game, the Bay Conservation and Development Commission, the Environmental Protection Agency, the Association of Bay Area Governments, and the State Water Resources Control Board. Most of the Regional Board's work is being conducted in the south bay as the shellfish beds in this area are of highest priority. Priority was based on shellfish populations, public use, and public access. Shellfish beds

#25 and #26 along the Brickyard shore are not among the ten shellfish beds studied by the Shellfish Program. The program, directed by marine biologist Fred Jarvis, is presently investigating sources of contamination to shellfish beds in order to determine cost-effective management practices needed to eliminate or reduce the contamination of beds by dry weather drainage.

<u>Suitability of Shellfish Resources for Recreational Harvesting</u>

According to the Department of Fish and Game, an area with a shellfish population of about 500,000 is suitable for recreational harvesting. The most current population surveys performed in the Berkeley Marina, which includes the Brickyard, have shown the shellfish populations to be stable at around 400,000. TABLE 1 gives a summary of shellfish population surveys along the East Bay shore.

Date of Survey	Estimated Bed Size (ft^2)	Location	*Tapes*	*Mya*	Other	Total	Source[b]
1968	22,800	Bed 25	42,960	48,600	---[a]	91,560	1
1972	800	Bed 26	0	8,000	---	8,000	1
1972	---	Bed 25	$11/m^2$	$27/m^2$	---	---	2
1972	1,134	Berk. Marina	24,948	61,236	---	86,184	2
1977	63,000	Bed 26	422,100	50,400	---	472,500	1
1980	54,300	Berkeley	209,000	11,600	225,300	445,900	3
1980	85,950	Berk. Marina	$12.8/ft^2$	---	---	1,103,765	3
1980	54,300	Berk. Marina	$3.8/ft^2$	---	---	225,300	3
1980	6,943	Bed 25	96,750	---	---	108,300	2
1980	1,776	Bed 25	---	11,550	---	11,550	2
1980	14,854	Berk. Marina	276,000	27,600	---	303,600	2

a = data not reported

b = Source: 1 - Jones and Stokes, 1977
2 - Sutton, J., 1981
3 - McAllister and Moore, 1982

TABLE 1. Summary of Shellfish Population.

It should be noted that none of the surveys include bay mussel populations, even though the southern half of the Brickyard shoreline is densely populated by them.

From the recent population estimates given in TABLE 1, it can be concluded that the shellfish resources appear to be suitable for recreational use. However,

factors such as recruitment and mortality rates, as well as the effect of increased harvesting, need to be studied in order to manage the present shellfish resources properly for recreational harvesting purposes.

Shellfish Standards

The quality of shellfish consumed by the public is of great concern to health agencies for three main reasons (Sharpe, 1977): (1) shellfish as filter feeders may concentrate bacteria and viruses up to 100 times and chemical contaminants up to several hundred times the values in overlying waters; (2) shellfish are often eaten raw or partially cooked; (3) the entire animal including stomach and digestive tract is consumed. Many problems exist in determining the acceptable levels of toxic contaminants in shellfish for human consumption, as the health effects of these contaminants depend on many factors, such as the consumer's physiological state of health, and frequency and quantity of species ingested (DOHS, no date). Some contaminants are not measurable with present laboratory techniques. This is the case for some viruses, such as the agent of infectious hepatitis. The lack of toxicological data has limited the number of established standards.

The U.S. Public Health Service has developed bacterial standards governing the harvesting of shellfish. These standards are based on measuring levels of total and fecal coliform bacteria in shellfish and shellfish-growing waters and using such data to indicate the potential presence of pathogenic bacteria (Cooper et al., 1981). To enumerate the number of coliform present, ten-fold dilutions of the sample are planted in a series of tubes of specialized media. The distribution of positive tubes among the dilutions can be related statistically to the number of coliforms present in the original sample, the Most Probable Number (MPN) (Cooper et al., 1976). TABLE 2 gives the coliform bacteria MPN standards set for shellfish-growing waters and shellfish meat.

The Food and Drug Administration (FDA) establishes levels for poisonous and deleterious substances in human food. Action levels are defined as those limits at or above which the FDA will take legal action to remove contaminated products from the market (Dept. of Fish and Game, 1982). TABLE 3 lists the FDA action levels for identified pollutants in shellfish.

As can be seen from TABLE 3, mercury is the only heavy metal which has a set concentration limit. However, the FDA has set alert limits for five other heavy metals found in shellfish, the softshell clam in particular. Alert levels are intended to be used as an indicator of growing area degradation due to pollution

Bacterial Standards for Shellfish-Growing Waters

The coliform median MPN shall not exceed 70/100 ml, and not more than 10% of samples shall exceed 230/100 ml, for a 5-tube decimal dilution test or 330/100 ml where a 3-tube decimal dilution test is used.

Fecal coliform median MPN of the samples shall not exceed 14/100 ml and not more than 10% of the samples shall exceed an MPN of 43 for a 5-tube decimal dilution test or 49 for a 3-tube decimal dilution test.

Bacterial Standard for Shellfish Meat

Shellfish are not considered for interstate commerce unless fecal coliform MPN is 230/100 grams of meat.

This standard is used only as a supplement to growing water standards.

TABLE 2. Bacterial Standards.
Source: Cooper *et al.*, 1980.

Substance	Action Level (ppm fresh weight)
mercury	1.0
aldrin/dieldrin	0.3
endrin	0.3
heptachlor and heptachlor epoxide	0.3
kepone	0.3
PCB	5.0

TABLE 3. FDA Action Levels for Identified Shellfish Pollutants
Source: Dept. of Fish and Game, 1982

and do not imply toxic levels in shellfish meats. Alert levels also sttempt to set concentrations above which further investigation and consideration from a public health point of view may be warranted (Bradford and Luoma, 1979). TABLE 4 lists FDA alert levels for heavy metals in softshell clams.

Metal	Alert Level (ppm wet weight)
Cadmium	0.5
Chromium	5.0
Copper	25.0
Lead	5.0
Zinc	30.0

TABLE 4. FDA Alert Levels for Heavy Metals in Softshell Clams.
Source: Jones and Stokes, 1977.

General Summary of Shellfish Contaminants

The following section is devoted to the review and summary of available data on the levels of contaminants in the shellfish in or around the Brickyard area. These contaminants include bacteria, viruses, paralytic shellfish poison, trace-metals, and synthetic organic compounds (i.e., pesticides). Contaminant levels are compared to the established or recommended tolerance limits from which one may infer the potential for safe consumption of these shellfish.

It must be kept in mind that studies from separate sources may not be comparable due to differences in sampling technique, location, and time. Despite these differences, general conclusions can be made. It is on the basis of these general conclusions and my own study that I will assess the potential for safe recreational shellfish harvesting in the Brickyard area.

Bacteria

Typhoid, salmonellosis, and gastroenteritis are examples of bacterial diseases that may be transmitted from the water to humans by shellfish (Kelly, 1971). Pathogenic bacteria may contaminate shellfish-growing waters, and consequently shellfish, from inadequately treated sewage, urban runoff, wet weather sewage overflowings and bypassings, and boat waste discharges (Jones and Stokes, 1977). TABLES 5-8 summarize bacterial surveys on water quality performed between Emeryville and the Berkeley Marina (refer to FIGURE 1 for sampling sites).

Date	Location (see FIGURE 1)						
	End of Berk. Pier TC/FC[a]	Marina Entrance TC/FC	Aquatic Park TC/FC	E-1 TC/FC	E-2 TC	E-3 TC	E-4 TC
1-19-73				11,000	2,400	2,400	4,600
2-8-73				430	290	2,400	930
3-5-73				430	230	2,400	4,600
4-5-73				930	930	930	>11,000
5-11-73				40[b]	90	90	≥24,000
6-13-73				1,500	4,600	2,100	4,600
7-11-73				2,400	11,000	2,400	≥ 2,400
8-6-73				90	930	4,600	≥24,000
9-12-73	75/9						
9-13-73	15/7	43/43					
9-14-73	93/9	43/23					
9-17-73	23/4	14/3					
9-21-73			>2,400/23				
9-24-73			240/9				

[a]TC = total coliform/100 ml
FC = fecal coliform/100 ml

[b]Underlined figures meet standards

TABLE 5. 1973 Coliform Bacteria Data.
Source: Sharpe, 1977.

Generally, the bacterial levels in the waters sampled exceed the standards set for shellfish-growing waters. Of all the water samples tested, only 22 met the standards (TC median MPN 70/100 ml and FC median MPN 14/100 m.). Of these 22, 18 were taken from the Berkeley Marina and Aquatic Park area. Low coliform levels in the Berkeley Marina could be due to the sewage pump-out facilities available there (Jones and Stokes, 1977). The high coliform levels on the shoreline appear to remain high throughout the year, although usually the worst bacterial conditions are expected during the rainy season when there is a great amount of urban runoff. This generality does not apply to the water quality results given in TABLES 5-8. The possibility of having seasonal harvesting even during the dry periods does not seem likely unless the bacterial levels can be drastically reduced.

The fecal coliform standard in shellfish meat is used as a supplement to growing water standards. And since high coliform levels were found in the

shellfish growing waters, this would lead one to expect that the shellfish meat also contains high coliform levels. This could probably be the reason why I did not find any bacteriological tests performed on shellfish meat from beds #25 and #26. I did find bacteriological results on shellfish meat from a test made in 1972 at a site near Albany Hill (Sharpe, 1977). None of these samples met the

	April 7-8, 1972	April 17-18, 1972	April 22-23, 1972
Albany Hill	13,000 MPN/100g	1,700 MPN/100g	7,000 MPN/100g

fecal coliform MPN standard of ≤230/100 grams of shellfish meat.

Due to the lack of current data on bacterial levels in shellfish meat, I tested some samples from the Brickyard area. See the Appendix for complete details on methods and techniques used in sampling. Below are the results from the bacteriological tests I performed on mussels of the Brickyard.

Brickyard	March 4, 1982	
	Total Coliform (MPN) 24,000/100 grams	Fecal Coliform (MPN) 3,113/100 grams

Date	A-1 TC/FC[a]	A-3 TC/FC	B-1 TC/FC	B-3 TC/FC	C-1 TC/FC	C-3 TC/FC	E-1 TC	E-2 TC	E-3 TC	E-4 TC
1-19-74							750	2400	4600	930
2-1-74							11000	1100	4600	24000
3-13-74	<u>62/13</u>[b]	<u>23/<4.5</u>	130/23	<u>23/<4.5</u>	130/23	<u>23/<4.5</u>				
3-14-74							1500	1500	2400	1500
3-15-74	2300/62	620/6	130/23	2300/<4.5	230/6	62/62				
4-9-74							≥24000	≥24000	≥24000	≥24000
5-23-74							230	430	2400	<u><30</u>
6-14-74							930	430	390	4600
7-9-74							≥24000	≥24000	≥24000	≥24000
8-16-74							2400	11000	440	≥24000
9-23-74							1500	4600	≥24000	≥24000
10-25-74							930	930	430	430
11-22-74							4600	430	230	2400
12-13-74							460	460	1500	1500

[a]TC = total coliform/100 ml
FC = fecal coliform/100 ml

[b]underlined figures meet standards

TABLE 6. 1974 Coliform Bacteria Data.
Source: Sharpe, 1977.

Date[b]	E TC[a]	F TC	G TC	Middle of Berk. Marina TC/FC	So. Edge Berk. Marina TC/FC	Berk. Marina near Bth H-5 TC/FC	Berk. Marina near Bth H-6 TC/FC	Berk. Marina near Bth I-6 TC/FC
1-16-76	110,000	240,000	2,300					
2-2-76	24,000	240,000	910					
3-1-76	24,000	240,000	15,000					
3-23-76	46,000	240,000	360					
4-13-76	24,000	240,000	910					
5-3-76	46,000	240,000	300					
5-17-76	24,000	240,000	7,500					
6-7-76	15,000	46,000	360					
6-23-76	24,000	240,000	360					
7-1-76	110,000	240,000	910	230/23	23/6[c]	4.5/4.5	62/62	4.5/4.5
8-2-76	110,000	46,000	910					
9-1-76	240,000	240,000	360					
9-29-76	240,000	110,000	24,000					
10-13-76	2,400	240,000	24,000					
11-12-76	110,000	240,000	24,000					
12-2-76	240,000	240,000	9,300					

Date	E TC/FC	F TC/FC	G TC/FC	Berk. Marina Entrance TC/FC	Berk. Seawall TC/FC	Marina Emeryville TC/FC
1-12-77	43,000/43,000	24,000/240,000	43,000/300			
2-8-77	93,000/21,000		2,400,000/290,000			
2-28-77				4/3	9/3	30/30
3-1-77				3/3	43/4	40/40

[a]TC = total coliform. FC = fecal coliform.

[b]1976 and 1977 data for sites E, F, G from Sharpe, 1977. Data for other sites from Jones and Stokes, 1977.

[c]Underlined figures meet standards.

TABLE 7. 1976 and 1977 Coliform Bacteria Data.

The MPN grossly exceeded the standards. This result serves to confirm the poor quality of the mussels, as well as that of the overlying waters.

Viruses

Human enteric viruses are excreted in the fecal matter of infected persons. The release of viruses into the marine environment via sewage outfalls and polluted waterways presents a threat to shellfish harvesting. Shellfish from polluted waters may transmit serious viral illnesses such as infectious hepatitis and meningitis (Jones and Stokes, 1977). It has been determined that coliform bacteria

Date	Potter Street Storm Drain TC/FC[a]	Shoreline 500 Yds. South of Gilman St. TC/FC
8-9-79	7,000/2,200	1,700/130
8-20-79	35,000/2,300	330/230
8-21-79	490/230	1,700/1,700
8-22-79	4,900/230	790/490
8-23-79	490/130	490/79
8-24-79	1,700/230	490/140
9-17-79	24,000/24,000	920/94
9-18-79	54,000/2,300	94/11
9-19-79	1,300/70	350/13
9-20-79	130,000/3,300	23/2[b]
9-21-79	140/40	540/49

[a]TC = total coliform. FC = fecal coliform.

[b]underlined figures meet standards.

TABLE 8. 1979 Coliform Bacteria Data.
Source: Jarvis, pers. comm., 1982.

are not useful for indicating whether or not shellfish are contaminated by human enteric viruses. Presently the only way to determine whether enteric viruses are contaminating shellfish is to measure them directly (Cooper and Johnson, 1981). Drs. Cooper and Johnson, from the U.C. Berkeley School of Public Health, concluded from their study of Tapes japonica in San Francisco Bay shellfish beds that the low levels of polio virus recovered suggest that these viruses may not pose a significant public health hazard. However, none of the beds they tested included those near the Brickyard. Also, a number of viruses, such as Hepatitis Type A and the Norwalk Agent, were not studied.

Paralytic Shellfish Poison

Paralytic shellfish poison (PSP) is produced by the marine dinoflagellate Gonyaulax catanella. PSP is an important concern for the following reasons (Jones and Stokes, 1977): (1) the poison is among the most potent known; (2) shellfish may be safe in an area for years and then suddenly become toxic; (3) the toxin is heat-stable and does not degrade during cooking; (4) shellfish themselves do not appear harmed by consuming Gonyaulax; and (5) there is no field method for distinguishing between poisonous and non-poisonous shellfish. Blooms of Gonyaulax

have a likelihood of appearing between May and October. Therefore, the California Department of Health issues an annual mussel quarantine from May 1 through October 31. Of all the shellfish, mussels concentrate the toxin to the greatest degree. Clams may be harvested as long as they are eviscerated before being consumed (Sharpe, pers. comm., 1982). The quarantine level for PSP is 80 mg/100 gm of shellfish meat (NSSP Manual of Operation, 1965).

In July of 1980 California had the second largest reported PSP incident in state history. Shortly after the outbreak, mussels from the Berkeley Marina and shoreline were tested for the presence of toxins. Mussel samples from both localities proved negative for toxin. However, mussels from Sausalito contained 960 mg of toxin. This result verified the need to continue to include bays and estuarine water bodies in the annual mussel quarantine (Sharpe, 1981).

<u>Trace Metals</u>

As can be seen from the list of FDA action levels, mercury is the only trace metal for which a strict limit has been set. In addition to mercury, cadmium and lead are toxic to humans at relatively low concentrations. Cadmium exposure in humans comes mainly from food, and the intestinal absorption of it is low. Food with high cadmium concentrations should be avoided because cadmium has a marked tendency to accumulate in the body.

Human exposure to lead comes from many sources. Five to ten percent of lead ingested with food and drink is absorbed into the body. Concentrations of lead in food must be fairly high before lead poisoning can occur from this source (Girvin <u>et al</u>., 1975). TABLE 9 summarizes data on trace metal levels at sites near Albany Hill and Point Isabel. Trace metal studies on shellfish beds #25 and #26 could not be found.

Point Isabel shellfish samples had gross contamination levels of lead, zinc, and cadmium. The high lead and zinc levels found in this area were attributed to heaps of electrical battery cases that had been dumped near the shore (see paper by John C. Thomas). The trace metal concentrations in the Albany Hill shellfish were below the FDA alert levels. However, high lead levels in dry weight measurements of shellfish samples were found in clams and a mussel sample. Bottom mud samples had high levels of mercury and zinc. These trace elements in the sediments would be available for uptake by shellfish (Sharpe, 1977).

Aside from these two places, the San Francisco Bay Shellfish Program has reported that most of the shellfish beds studied have trace metal concentrations

Location	Species	Cd	Cr	Cu	Pb	Hg	Zn	Source
Albany Hill	---[a]	.21	3.64	6.60	<u>18.70</u>[b]	.06	24.53	1
	Tapes	.40	1.20	1.40	3.20	.08	23.40	2
	Mya	.27	1.20	4.81	2.20	.07	17.00	3
	Mytilus	.47	1.20	1.50	2.96	.04	24.80	3
Point Isabel	*Tapes*	.30	.30	.90	<u>7.30</u>	.04	19.50	4
		.30	.20	.90	<u>6.20</u>	.04	18.70	4
		.39	.23	.80	<u>135.00</u>	.03	22.10	4
	Mya	.10	.20	2.80	<u>8.50</u>	.03	21.50	4
		.10	.30	2.80	<u>9.60</u>	.04	21.60	4
		.07	.20	3.10	<u>47.00</u>	.03	22.50	4
	Mytilus	<u>.80</u>	.20	1.20	<u>64.00</u>	.06	<u>53.70</u>	4
		<u>.60</u>	.30	.90	<u>43.00</u>	.06	<u>37.50</u>	4
		<u>.80</u>	.19	.90	<u>81.00</u>	.03	28.00	4

[a]Data not reported

[b]Underlined figures exceed alert limits

TABLE 9. Concentrations of Selected Trace Metals in PPM (mg/kg) Wet Weight.

Source: 1 - EPA, 1972
2 - Girvin *et al*., 1975
3 - Jones and Stokes, 1977
4 - McCleneghan, K., 1980

below existing or recommended FDA action levels (McCleneghan, 1980).

Synthetic Organic Compounds

Of the synthetic organic compounds, chlorinated hydrocarbons are one of the most important due to their wide use, great stability in the environment, and toxicity to certain forms of wildlife. If absorbed into the human body, they tend to be accumulated in fatty tissues rather than metabolized (Jones and Stokes, 1977). TABLE 10 summarizes levels of synthetic organic compounds in shellfish at Albany Hill and Point Isabel. I could not find data for the Brickyard shellfish.

Point Isabel shows a greater number of different pesticides and in higher concentrations than those found in Albany Hill. However, all of these levels are below existing or recommended FDA Action levels. The San Francisco Bay Shellfish Program has also consistently reported that most shellfish beds they have studied are well within the standards (McCleneghan, 1980).

Location	Species	Arochlor	Dieldrin	op'DDE	ppDDE	opDDD	opDDD	ppDDD	pp'DDT	PCB 1254	Trans-chlordane	Cis-chlordane	Trans-nonachlor	Oxy-chlordane	Source
Albany Hill	---[a]	88.0	4.0	7.2	2.0	1.2	1.6	2.8	3.6						1
	Tapes	38.1			6.91			5.0	3.46						2
	Mya	39.2			6.02			4.84	2.22						2
	Mytilus	138.0			16.4			10.6	7.27						2
Point Isabel	*Tapes*		5		5			5	5	50	5	5	5	5	3
					5	5		10	5	100	5	5	5		3
					5	5		8	5	50	5	5	5		4
	Mya		5		5			5	5	50	5	5	5	5	3
					9	5		10	5	85	5	5	5		3
					14	5		13	5	170	5	5	5		4
	Mytilus		7		36			62	5	380	20	20	14	5	3
					44	13		69	7	660	23	36	31		4
					36	12		47	5	630	15	23	15		4

[a]Data not reported

TABLE 10. Summary of Synthetic Organic Compounds in PPB Fresh Weight.

Source: 1 - EPA, 1972
2 - Girvin *et al.*, 1975
3 - McCleneghan, K., 1980
4 - Calif. Dept. of Fish & Game, 1982

Discussion

The potential for shellfish harvesting in the Brickyard with respect to shellfish resources, contaminant levels in shellfish, and public health standards, is severely hampered by the high levels of bacterial contamination in the overlying waters, as well as in the shellfish meat. The reported coliform levels generally exceeded the public health standards of 230 coliform/100 ml throughout the year. Even during the summer, when the lowest bacterial levels are expected due to minimum rainfall runoff, the shoreline water around the Brickyard showed up to 240,000 coliforms/100 ml. Apparently, the University Avenue storm drain and Strawberry Creek, which also flows into the same storm drain, discharge waters heavily contaminated with coliform bacteria all year round. A program to clean up the creek as well as one that would control surface runoff is needed if bacterial levels are ever to meet public health standards at this location.

One way to enhance the possibility of shellfish harvesting in light of high bacterial levels would be to establish depuration plants. Depuration refers to the practice of placing contaminated shellfish in a controlled environment where rapid elimination of contaminants takes place (Jones and Stokes, 1977). Shellfish can quickly eliminate bacterial contaminants with a residence time in depuration tanks of 48-72 hours. If there were a depuration plant in the Bay Area, it could offer the sports clammer depurated clams in return for undepurated ones at a nominal charge (Jones and Stokes, 1977).

As for the other substances examined in this study, they generally do not seem to pose any serious problems. For instance, the shellfish resources are sufficient to be considered for recreational use. And the levels of viruses, PSP, trace metals, and synthetic organic compounds in shellfish beds near the Brickyard, and those studied by the San Francisco Bay Shellfish Program, have generally met the standards or recommended alert levels, with the exception of Point Isabel and Albany Hill, which showed gross contaminations by metals and high levels of pesticides. It is important to note that few data are available on the levels of these contaminants found in shellfish specifically at the Brickyard. This is in part due to the fact that there is no agency responsible for monitoring the levels of these contaminants in shellfish in the San Francisco Bay. Therefore, the general findings of past studies may not necessarily apply to the shellfish along the Brickyard shores. Considering the complexity of water circulation within the bay, sources of pollution from places beyond the immediate study area, such as East Bay Municipal Utility District Waste Water Treatment Plant, Berkeley Dump, and industries

along the waterfront, might affect the shellfish quality of the Brickyard area. This possibility needs to be studied.

Conclusion

In doing this research, I have found that a complete sanitary survey needs to be conducted in order to ascertain whether high levels of bacterial contamination are the only barrier to the safe consumption of shellfish. The survey should include an evaluation of all potential and actual sources of pollution to the Brickyard shore. If in fact high levels of bacteria contamination proves to be the only danger to human's consumption of shellfish in this area, then it would seem worthwhile to pursue the idea of establishing recreational harvesting with safeguards. Many people would stand to benefit from this, especially those who presently shellfish in order to supplement their diets. And as proteinaceous foods are becoming more expensive, it is possible that many more people will be attracted to shellfishing.

APPENDIX

Examination of Shellfish for Total Coliforma and Fecal Coliforms

Total and fecal coliform bacteria levels in shellfish samples were determined as per Recommended Procedures for the Examination of Sea Water and Shellfish (APHA, 1970). Processing was initiated within 24 hours of sample collection.

Sample collection data:

Date: 3-4-82

Time: 11:00 a.m. - 2:00 p.m.

Location: See FIGURE 1. "X" marks the collection sites.

Samples collected consisted of 27 legal-sized Bay Mussels (1½" or larger) and 5 Japanese littleneck clams. As not enough clams were found to obtain a representative sample, the experiment was based solely on mussels.

At 2:00 p.m. mussels were refrigerated until 11:00 a.m. of the next day, a total of 21 hours.

Laboratory data

Weight of mussel meat and liquor = 331 g.

By mistake 331 ml of stock buffered water was added instead of 331 ml of buffered dilution water.

Presumptive test results after 79 hours of incubation:

5 positive tubes for 1 g, 0.1 g, and 0.01 g dilutions. All dilution tubes with 0.001 g were negative. Most Probable Number for 5, 5, 0, positive test tubes = 24,000/100 g.

(continued)

APPENDIX

(continued)

Inoculated BGB and EC broth with cultures from the 0.01 dilution tubes, planting 3 portions for each tube (3-9-82 at 3:00 p.m.).

Confirmative test results (3-10-82 at 2:00 p.m.)

4 positive tubes and 11 negative tubes of EC broth

$$MPN = \frac{100 \times P}{N \times T}$$

P = # of positive tubes
N = # of negative tubes
T - Total volume tested

$$\text{MPN of fecal coliform} = \frac{100 \times 4}{.11 \times .15} = 3113/100 \text{ g of mussel meat}$$

(3-11-82 at 2:00 p.m.). All 15 tubes of BGB were positive, therefore MPN of total coliform is confirmed to = 24,000/100 g of mussel meat.

REFERENCES CITED

American Public Health Association (APHA), 1970. Recommended procedures for the examination of sea water and shellfish, 4th ed.: American Public Health Association, New York, 105 pp.

Bradford, W. and S.N. Luoma, 1979. Some perspectives on heavy-metal concentrations in shellfish and sediment in San Francisco Bay, California: U.S. Geological Survey, unpublished data, 69 pp.

California Department of Fish and Game, 1982. Investigations of selected environmental contaminants in San Francisco Bay shellfish: A report to San Francisco Bay Shellfish Program, S.F. Bay Regional Water Quality Control Board. Laboratory report No. 82-1, 36 pp.

California Department of Health Services (DOHS), n.d., Breuer, Robin: unpublished data.

California Regional Water Quality Control Board (RWQCB), S.F. Bay Region, 1978. Internal Memo: Staff report on the Regional Board Program to open shellfish beds for recreational use, from F. Jarvis to F. Dierker, March 2, 1978. File No. 1460.00.

__________, 1978. Resolution No. 78-8 (Policy Statement with respect to the Regional Board Program to open S.F. Bay shellfish beds for direct recreational use), Attachment #1, 10 pp.

__________, 1980. Information sheet on the S.F. Bay Shellfish Program, (March), 1 p.

__________, 1980. Annual Progress Report, October: Prepared by F. Jarvis, 3 pp.

__________, 1981. S.F. Bay Shellfish Program Preliminary sanitary survey report for the East Bay study area: 263 pp.

__________, 1982. Annual Progress Report, January: Prepared by F. Jarvis, 3 pp.

Cooper, R.C., D. Jenkins, L. Young, 1976. Aquatic microbiology laboratory manual: Prepared by Association of Environmental Engineering Professors under EPA grant No. T-900457001-4, III-E-2-6p.

Cooper, R.C., K.M. Johnson, D.C. Straube, and D. Koyama, 1981. Detection of human enteric viruses and coliform bacteria in S.F. Bay waters and shellfish: Sanitary Engineering and Environmental Health Research Laboratory, College of Engineering and School of Public Health, U.S. Berkeley, SEEHRL Report No. 81-1, 76 pp.

Girvin, D.C., A.T. Hodgson, and M.H. Pantetz, 1975. Assessment of trace metal and chlorinated hydrocarbon contamination in selected San Francisco Bay estuary shellfish: Lawrence Berkeley Lab, University of California, UCID-3778, 82 pp.

Jarvis, F., San Francisco Bay Shellfish Project Manager, RWQCB. Personal communication, April, 1982.

Jones & Stokes Assoc., 1977. An assessment of the potential for commercial and recreational harvesting of S.F. Bay shellfish: Prepared for Association of Bay Area Governments, Claremont Hotel, Berkeley, CA, 171 pp.

Kelly, C.B., 1971. The health hazards associated with the consumption of shellfish from polluted waters: Environmental Protection Agency Division of Water Hygiene, 21 pp.

McAllister, F.D., and T.O. Moore, Jr., 1982. Selected shellfish resources of San Francisco Bay: their distribution, abundance, use, public access and recommended management alternatives: California Department of Fish and Game. A report to to San Francisco Bay Shellfish Program, 168 pp.

McCleneghan, K., 1980. San Francisco Bay shellfish study, February 1980: Trace metal and synthetic organic compound concentrations in selected bivalve mollusks: California Department of Fish and Game; Fish and Wildlife Water Pollution Control Laboratory, Lab. memorandum Report No. 80-2, 23 pp.

Sharpe, C.A., 1977. An analysis of the factors affecting the possible establishment of a commercial shellfish operation in San Francisco Bay along the Berkeley shoreline: State Department of Health Sanitary Engineering Section, 52 pp.

__________, 1980. Paralytic shellfish poison: California Department of Health Services, Sanitary Engineering Section, 75 pp.

__________, Senior Sanitary Engineer, State Health Department. Personal communication, May 1982.

Sutton, J.E., 1981. Shellfish resources of eastern S.F. Bay: Distribution, abundance, public access and use. Prepared for East Bay Municipal Utility District, Special District No. 1. Jefferson Associates, Inc., S.F., CA, 168 pp.

U.S. Environmental Protection Agency, 1972. Water quality sources of pollution and abatement needs for S.F. Bay, Calif.: Preliminary Draft: National Field Investigations Center, Denver, Colorado and Region IX, San Francisco, California, VIII, 11 pp.

__________, 1974. Shellfish study of San Francisco Bay, April-June, 1972, Technical Report-EPA-909/9-74-003: Surveillance and Analysis Division, 23 pp.

U.S. Department of Health, Education, and Welfare, 1965. National shellfish sanitation program manual of operations Part I: Sanitation of shellfish growing areas: Division of Environmental Engineering and Food Protection, Shellfish Sanitation Branch, Washington, D.C., 32 pp.

Vandre, V., 1980. Harvesting of clams, mussels, and oysters, a real possibility: Outdoor California, v. 41, no. 4, pp. 4-6.

Chapter 3

HAZARDOUS WASTE SITES ALONG THE EASTBAY SHORELINE

John Cruz Thomas

The United States in 1980 generated between 30 to 40 million metric tons of hazardous wastes (EPA, 1980). This translates into nearly 300 to 400 pounds of wastes per person. The Environmental Protection Agency (EPA) foresees a doubling of annual hazardous waste generation by the year 2000 (CBE, 1981). A 1972 study of San Francisco Bay has indicated that human-related activities may be responsible for 15 elements in detectable concentrations (Peterson _et_ _al_., 1972). Considering the present set of circumstances and the EPA's grim prognosis, a close examination of hazardous waste as a threat to human health and the environment is of extreme importance. Therefore, plans for future East Bay shoreline development would not be complete without a thorough investigation of hazardous waste sites within the proposed region.

Whenever resources are converted into goods, waste is generated and much of it is hazardous. According to the Resource Conservation and Recovery Act, a waste is hazardous if, "because of its quantity, concentration, or physical, chemical or infectious characteristics it: (a) causes or significantly contributes to an increase in mortality or an increase in serious irreversible or incapacitating reversible illness; or (b) poses a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, or disposed of or otherwise managed" (EPA, 1980, p. 4). Certain natural materials become hazardous when they have been concentrated or released into the environment or because processes have changed materials into hazardous substances. These substances may be ignitable, reactive, corrosive, radioactive, infectious, or toxic. They may exist as solids, liquids, sludges, powders, and slurries; but about 90 percent are liquid (Goodman, pers. comm., 1982). Some of these wastes are non-degradable and persist in nature indefinitely.

Before presenting the following case studies, we will look in detail at three types of hazardous waste, polychlorinated biphenyls (PCB), chromium, and lead. A discussion of these waste types is essential because they play major roles in each

study.

PCBs were first identified in 1881 and first used in 1929. There about 210 possible PCBs, of which around 102 are probable (Kruus and Valeriote, 1979). PCBs are inert chemically and have high dielectric constants, properties which explain their suitability for many industrial purposes. They are not soluble in water and are unaffected by acids, bases or corrosive chemicals. They have high boiling points and may be heated and boiled without decomposing. They are related to DDT but are even less biodegradable than that substance. Thus, although their stability makes them ideal for many industrial uses, this same stability makes them very persistent chemicals in the environment.

PCBs have been found widely dispersed (even in Antarctica), in many fish and birds, in human and animal fat tissue, in milk, food, plankton, snow, industrial waste discharge, river-bottom sediments and lactating women's milk (Kruus and Valeriote, 1979). The PCB in the environment accumulates in living organisms because it prefers organic media such as body fat to water.

The health effects of PCBs have been studied in animals and, to a lesser extent, observed in humans. In several animal species (birds, monkeys) reproductive processes have been shown to be affected; livers enzyme systems and immunities of some animals are also affected (Kruus and Valeriote, 1979). Several studies on rodents suggest strongly that some PCBs are carcinogenic, and that they can enhance the carcinogenicity of other chemicals (Sittig, 1980). It is known that PCBs can cause skin disorders in humans, and the chemical has been implicated in human cancers in workers exposed to it (Kruus and Valeriote, 1979).

Chromium is included in the group of heavy metals designated by the EPA as hazardous substances. Much of the detectable chromium in air and water is presumably derived from industrial processes, which in 1972 consumed 320,000 metric tons of the metal in the U.S. alone (Sittig, 1980). Chromium is used in chrome plating, copper stripping, aluminum anodizing, as a catalyst, in refractories, inorganic synthesis, and photography (Sittig, 1981). Chromium is also used in cooling waters, in the leather tanning industry, in pigments and primer paints, and in fungicides and wood preservatives (Sittig, 1980). Chromium is water soluble; therefore, if it exceeds permissible concentrations in water, aquatic life and human health can be threatened.

Chromium compounds are irritants and corrosive, and can enter the body by being swallowed, inhaled or by penetrating the skin. Acute exposure to dust or mist may cause coughing and wheezing, headache, fever, and loss of weight. The

corrosive action that chromium has on the skin results in small ulcers about the size of a matchhead. These ulcers tend to be quite deep, heal slowly and leave scars. Liver injury and increased risk of lung cancer have been reported from exposure to chromium (Sittig, 1981).

Lead is also a heavy metal and has been deemed by the EPA to be a hazardous substance. Lead is a soft, malleable, stable, heavy, bluish-grey metal. It reaches the aquatic environment through precipitation, fallout of lead dust, leaching from soil, street runoff, and both industrial and municipal wastewater discharges (Sittig, 1980). Lead consumption in the U.S. is about 1.3×10^6 metric tons annually. Approximately half of that consumption has been for the manufacture of storage batteries, and one-fifth has been for the manufacture of gasoline anti-knock additives. Pigments and ceramics account for about 6 percent of annual production. All other major uses are for metallic lead products or for lead-containing alloys (Sittig, 1980).

Lead affects the nervous system, the kidneys, and red blood synthesis in humans. The early symptoms of lead poisoning include stomach ache, weakness, irritability, and fatigue. In later stages, the victim may experience headaches, loss of appetite, drowsiness, vomiting, cramps, clumsiness, or convulsions. Finally, it can lead to a deterioration of the central nervous system, produce sterility, paralysis and eventual death (Kruus and Valeriote, 1979).

It has been reported that in the U.S. approximately 100 children die of lead poisoning each year; 12,000 to 16,000 are treated and survive, but at least one quarter of these suffer permanent injury (Kruus and Valeriote, 1979). Children's vulnerability to lead poisoning is possibly related to their pica for paint chips or for soil. Women are another group that have a higher likelihood of experiencing adverse effects from lead exposure. This is due to the fact that their blood-forming system is more lead-sensitive than men's (Sittig, 1980).

Case Studies

Historically, the major industries of Alameda County were located along the shoreline. The water's edge is the center for industrial activity because of easy access for products, import and export by boat, rail or air transport. The shoreline is also the location for municipal and industrial waste disposal. In the following section, two hazardous waste sites in Alameda County and one in Contra Costa County will be discussed (FIGURE 1). These are only a few examples of many possible hazardous waste sites in the two counties. The reason for isolating these sites is because of their importance with respect to the bay.

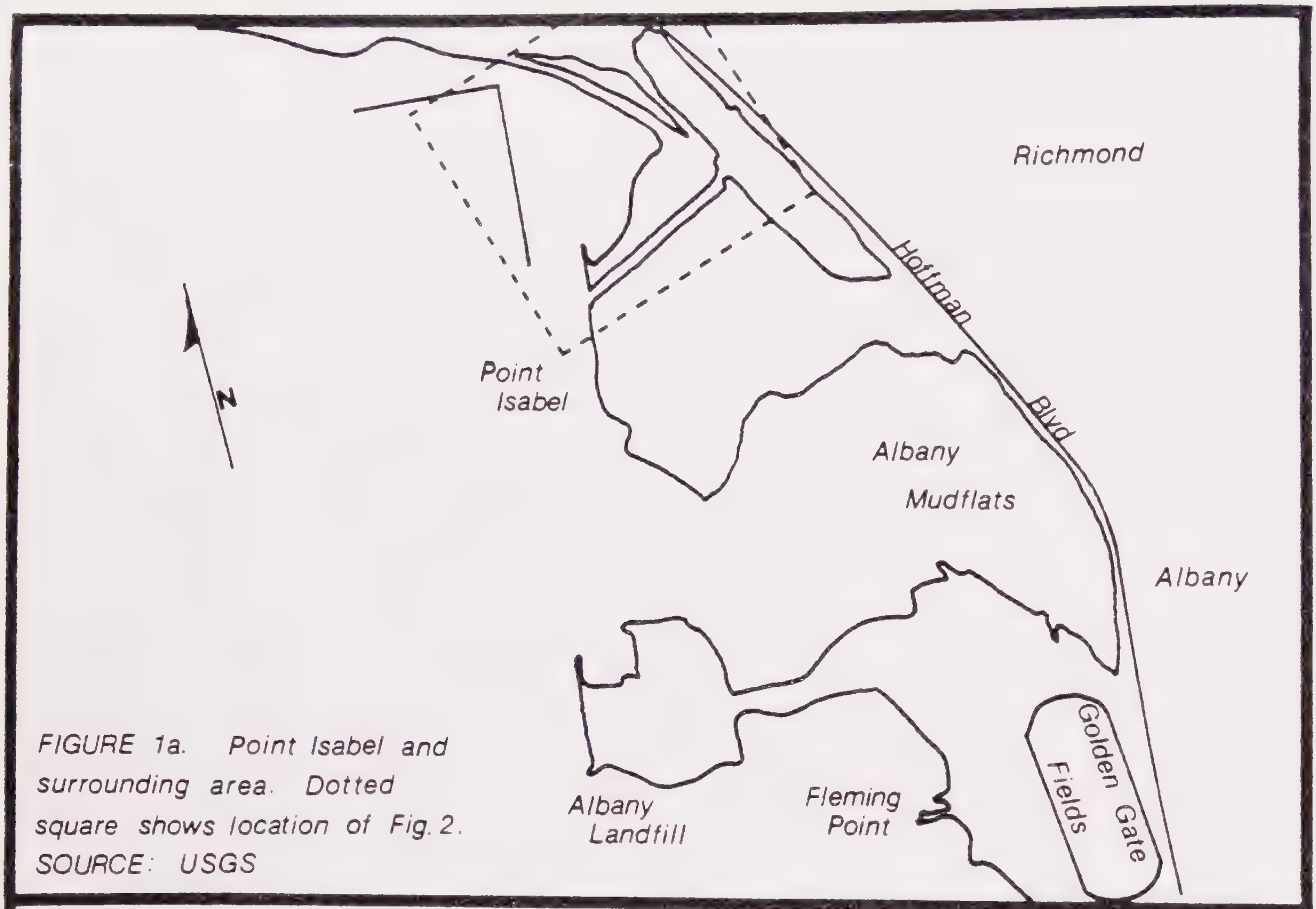


FIGURE 1a. Point Isabel and surrounding area. Dotted square shows location of Fig. 2. SOURCE: USGS

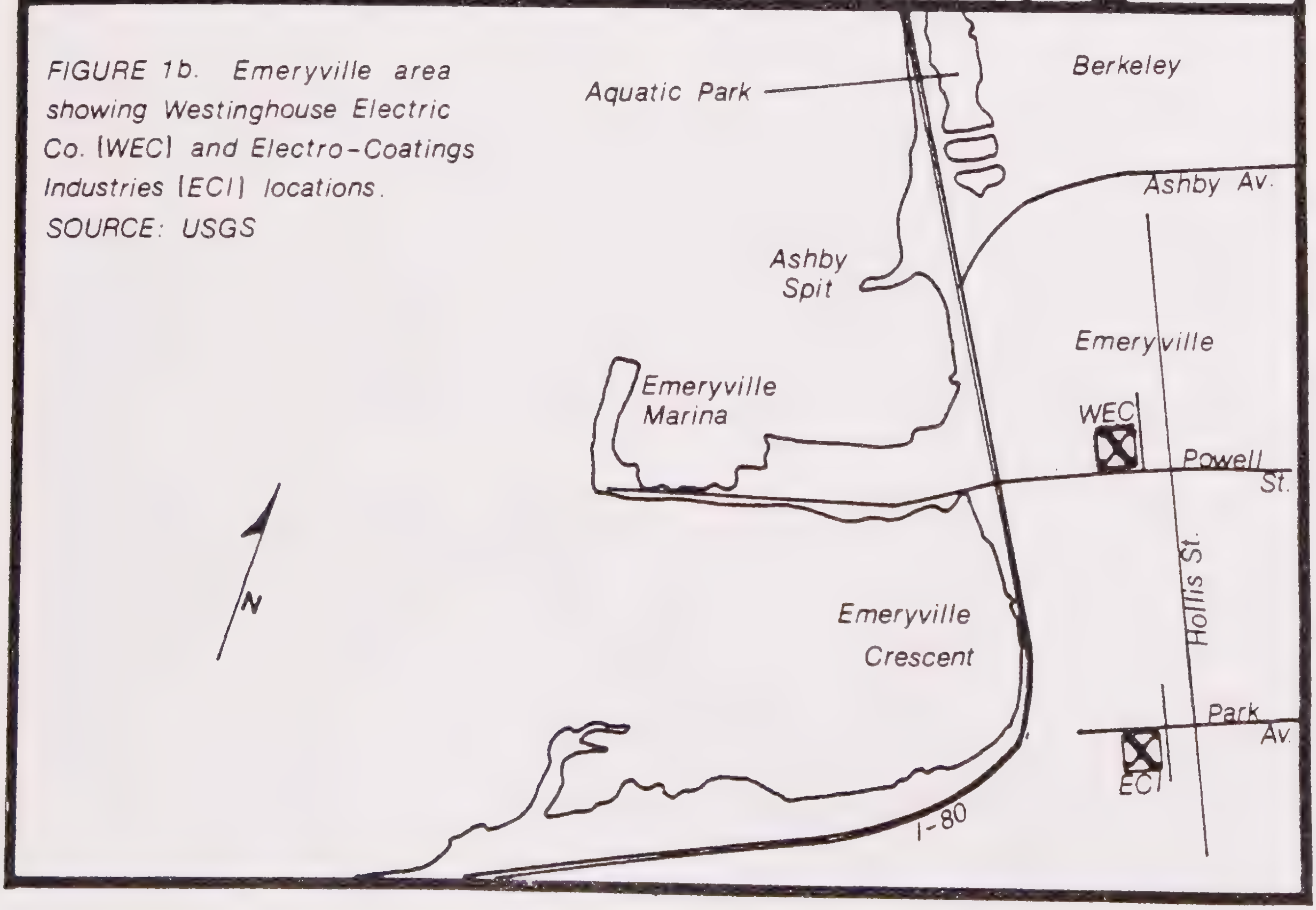


FIGURE 1b. Emeryville area showing Westinghouse Electric Co. (WEC) and Electro-Coatings Industries (ECI) locations. SOURCE: USGS

Westinghouse Site

Westinghouse Electric Company (WEC) (FIGURE 1b) began operations at its site in 1924. In the 1940's, WEC manufactured equipment for the transmission, use, and control of electricity. Since that time, this site has been used for transformer repair and maintenance work (Goodman, pers. comm., 1982).

During a 1981 field check of the site by the Department of Health Services - Abandoned Site Project (DOHS-ASP) staff, discolored soil was noticed along a railroad spur outside the enclosed WEC area. Transformers were visible in this enclosed area. Initial soil samples collected by the DOHS-ASP staff showed very high levels of PCBs. The contaminated area was subsequently barricaded and the site referred to the EPA for enforcement (Goodman, pers. comm., 1982).

In October 1981, the firm of Brown and Caldwell prepared a report of the WEC property for the EPA (Samaniego, pers. comm., 1982). The investigation was undertaken to determine the extent of PCB contamination on the property adjacent to the plant. The results show PCBs in significant concentration to a depth of 11 feet. Two possible explanations may account for the significant vertical migration. The PCBs may have been buried (a 1950 aerial photograph shows what looks like a waste disposal pond on the property). The other possibility is that the PCBs were carried into the ground by solvents (chlorobenzenes may have been used to clean remaining PCBs from transformers after they were drained). Proving these possible explanations for vertical migration of PCBs is difficult, as WEC has not cooperated in providing information on past practices or documentation (Samaniego, pers. comm., 1982).

The results of the Brown and Caldwell report leave many questions unanswered. For one, the total extent of vertical migration of PCBs was never determined, since drilling by the firm stopped at arbitrary depths. The extent of sub-surface migration off the testing site was not considered. Also, the amount of groundwater contamination was not determined. This is of importance because the groundwater table in Emeryville is shallow (4 feet below the surface, in some areas) (Samaniego, pers. comm., 1982). Lastly, the possible threat to the bay from surface runoff of PCBs must be addressed.

At the present time, the Regional Water Quality Control Board (RWQCB) is the local agency involved in working with WEC on clean-up or mitigation measures. To obtain necessary data, RWQCB requested EPA to have WEC do a detailed hydrogeological study of the area (Samaniego, pers. comm., 1982). There has been no clean-up activity at the WEC site to date. An estimated cost of clean-up is between

$10 to 15 million (CBE, 1981).

Electro-Coatings Site

Electro-Coatings Industries (ECI) began plating operations at the Emeryville location (FIGURE 1b) in 1963. This site was previously occupied by Industrial Hard Chrome. Between 1964 and 1965, ECI disposed of chromic acid plating wastes in an on-site shallow disposal well (Goodman, pers. comm., 1982). RWQCB received information regarding the disposal of the wastewater and ordered ECI to stop disposal. ECI ceased use of the well and turned to hauling waste to off-site disposal facilities (Samaniego, pers. comm., 1982).

Subsequent analysis of the groundwater was made by the firm of Woodward-Clyde. This investigation, referred to as Phase I by RWQCB, showed chromium contamination in significant quantities to a depth of 30 feet beneath the ECI site. Groundwater exists in the vicinity of the site at a depth of approximately 7 feet. The direction of groundwater movement in the area is westerly. Therefore, the contaminated groundwater will tend to move in that direction, i.e., towards the bay. The movement of the chromium-contaminated groundwater is between 2 to 122 feet per year. Although there is no solid evidence of the contaminated groundwater reaching the bay, this possibility is of concern to the RWQCB (Samaniego, pers. comm., 1982).

In spite of the fact that the Phase I investigation showed that groundwater contamination exists, it did not go into enough detail. A Phase II study by the firm of Klienfelder and Associates is underway better to define the extent of horizontal and vertical chromium contamination. This study will assist RWQCB and ECI in determining the type and feasibility of clean-up procedures (Samaniego, pers. comm., 1982). It is estimated that clean-up costs at the ECI site will be about $1 million (CBE, 1981).

Point Isabel

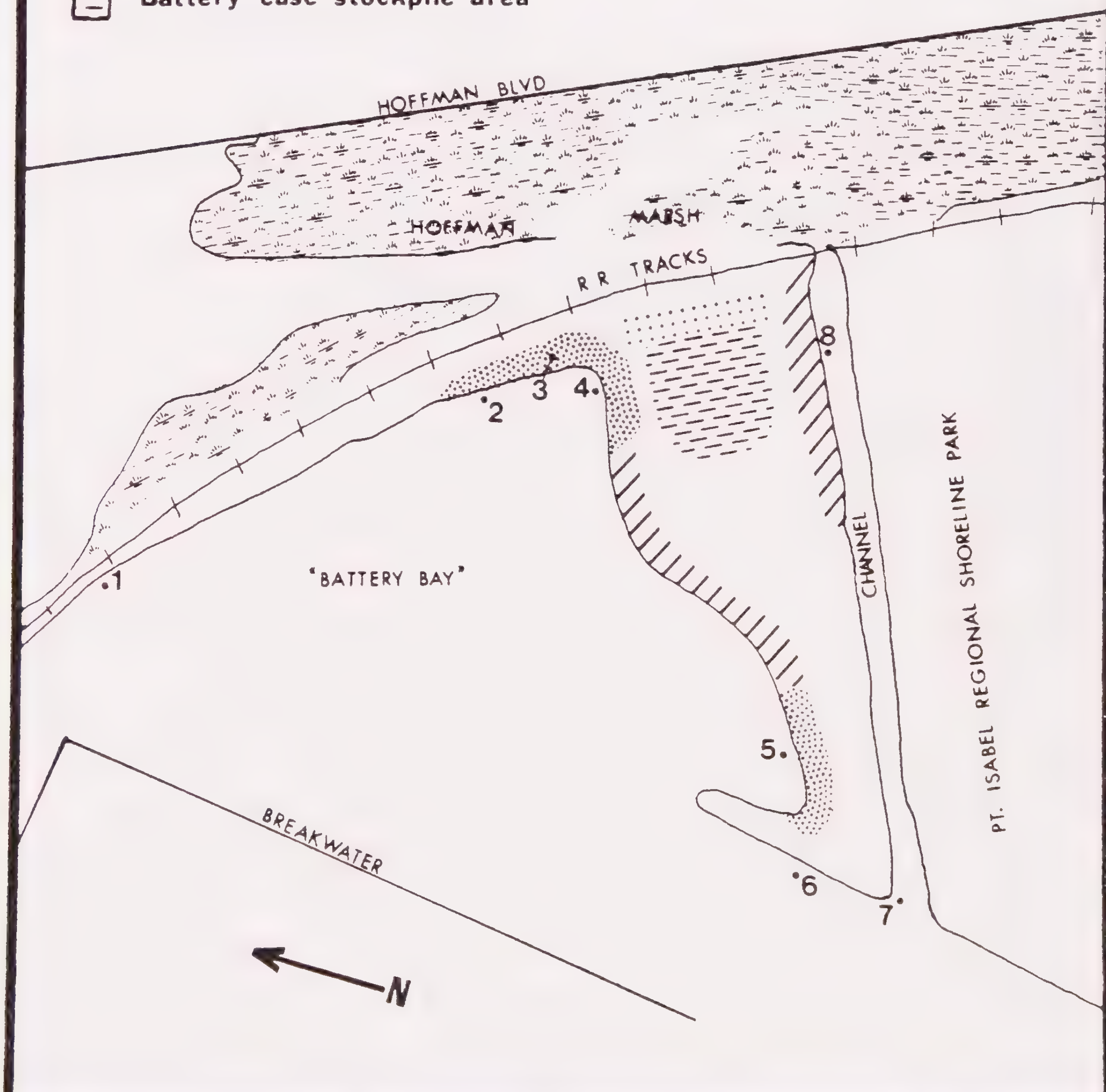
The Point Isabel site (FIGURE 1a) has been owned by Santa Fe Land Co., Inc. since the 1940's. Aerial photographs reveal that solid waste disposal on the property began in the early 1960's. Staffs of the RWQCB, DOHS-ASP, State Department of Fish and Game (DFG) and the U.S. Army Corps of Engineers all have observed large volumes of shattered automobile battery cases on the filled land just north of Point Isabel REgional Shoreline Park (FIGURE 2) (Goodman, pers. comm., 1982). The DFG and RWQCB have indicated that these battery cases may be responsible for

FIGURE 2. POINT ISABEL SITE. LOCATION of SOIL & SEDIMENT SAMPLES and BATTERY CASES. FOR SITE LOCATION SEE FIG. 1a.

SOURCE: COX, UNPUBLISHED DATA.

LEGEND

- Heavy deposits of battery cases
- Light deposits of battery cases
- Battery case roadbase area
- Battery case stockpile area



the high concentration of lead detected in shellfish in the area. Levels of lead obtained were maximum 9.6 ppm in clams, 64.0 ppm in mussels (Cox, pers. comm., 1982). The alert level of the U.S. Food and Drug Administration is 5 ppm (Jones and Stokes, 1977). Signs banning shellfish fishing in the area have been posted. Clammers, nevertheless, have been observed in the contaminated site by RWQCB staff (Goodman, pers. comm., 1982).

The crushed battery casings have affected the soil as well, polluting the area with lead compounds. These battery casings have also been deposited near and in the bay water tidal zone, contaminating the sediments in the bay waters. Soil and sediment grab samples have been analyzed and have been found to contain high concentrations of lead (TABLE 1).

These results show that significant concentrations of lead compounds exist on the property. The Contra Costa County Health Services Department (CCCHSD) has set 50 mg/kg as the maximum allowable level for lead in soil and sediment (Shahid, pers. comm., 1982). Santa Fe Land Co., Inc. has been directed by the CCCHSD, under Section 66336 of the California Administrative Code, to remove all contaminated materials from the Point Isabel site (Cox, pers. comm., 1982). An estimated figure for clean-up costs is $10 million (CBE, 1981).

Conclusion

Man has continually burdened the ocean environment with criminally negligent handling of hazardous substances. The three kinds of hazardous wastes that have been discussed are only a handful in a bay seemingly overwhelmed with such contaminants. While providing numerous societal benefits, modern technology has also brought about a marked increase in the number and variety of pollutants entering natural surface and sub-surface waters.

The PCBs and chromium from the WEC and ECI sites can have adverse effects on the Emeryville Crescent and the proposed Berkeley Beach area. The Crescent's fragile ecosystem and endangered species, and the beach with its crowds of recreating people are likely to gain harmful exposure through contact with contaminated surface, subsurface, and drinking water. It is possible that surface runoff is carrying PCBs from the WEC site into the bay. It is also likely that ECI's chromium problem is contributing both to contaminated subsurface waters reaching the bay and pollution of local aquifers. The seriousness of lead contamination at Point Isabel is evidenced by the results in TABLE 1. Lead concentrations in soil and sediment are so significant that, in one sample, the maximum allowable level is

SAMPLE NUMBER	SAMPLE DEPTH	LOCATION/DESCRIPTION	CONC. mg/kg
1a	Surface	Shoreline, NW of Battery Bay; half-way between jetties; 6' out from edge of rocks / soft, brown mud	93
1b	1 ft.	Same as 1a / clayey-silty, dark brown to black mud.	165
2a	Surface	Shoreline, N side of battery case mount, Battery Bay at edge of intertidal rocks / soft brown mud.	296
2b	1 ft.	Same as 2a / dark brown to black mud.	308
3a	Surface	Above high tide line, beneath battery cases (about 1' deep), about 15' bay-ward from a big wood beam / sandy-sooty sediment.	857
3b	1½ ft.	Same as 3a / same as 3a.	693
4a	Surface	Shoreline, Battery Bay, about 35' SW from sample #3, about 15' out from edge of rocks / dark brown to black mud.	449
4b	1 ft.	Same as 4a / same as 4a.	240
5a	Surface	Shoreline, SW of Battery Bay in the cove; at edge of battery cases in the mud; battery cases inter-bedded in 5-6 ft. high landfill bank above high tide / very soft, black mud.	329
5b	1 ft.	Same as 5a / same as 5a.	640
6a	Surface	On the S.F. Bay side, directly across the jetty from the cove, edge of riprap / silty, sandy sediment.	58
6b	1 ft.	Same as 6a / same as 6a.	52
7a	Surface	Mouth of Pt. Isabel channel, just N of the middle / sandy sediment.	62
7b	1 ft.	Same as 7a / same as 7a.	55
8a	Surface	Pt. Isabel channel about 80' up from railroad bridge on N side near battery cases in the mud / soft black mud.	173
8b	1 ft.	Same as 8a / same as 8a.	150

TABLE 1. Lead Concentrations in Soil and Sediment at Point Isabel. Samples located on FIGURE 2.

Source: Cox, unpublished data.

exceeded by over 800 mk/kg. Such pollution has brought about restrictions to recreational activities such as shellfish harvesting.

It is clear, then, that before full recreational activities can be enjoyed along the East Bay shoreline, these sites must be thoroughly cleansed of

contaminating materials. Westinghouse Electric Company, Electro-Coatings Industries, and Santa Fe Land Co., Inc. are slow in assuming their responsibilities. Public awareness and involvement and stronger stands by federal, state, and local agencies may be the spark that generates necessary action. As our understanding of the aquatic environment has grown, it has become clear that the capacity of our rivers, lakes, oceans, and aquifers to absorb chemical waste and toxic materials discharged into them is not at all infinite and that serious degradation of water quality is the inevitable result of misuse and mismanagement of this invaluable resource.

REFERENCES CITED

Citizens for a Better Environment, (CBE), 1981. On-Site Hazardous Waste Management in the San Francisco Bay Area, 144 pp.

Cox, Joanne, Waste Management Specialist, California Regional Water Quality Control Board, personal communication, 1982.

Goodman, Janet, Project Assistant, Department of Health Services Hazardous Materials Management Section, Abandoned Site Project, personal communication, 1982.

Jones and Stokes Associates, Inc., 1977. San Francisco Bay Shellfish: An Assessment of the Potential for Commercial and Recreational Harvesting, for Association of Bay Area Governments, 171 pp.

Kruus, P., and Valeriote, I.M., 1979. Controversial Chemicals, a Citizen's Guide: Canada, Multiscience Publications Limited, 243 pp.

Peterson, D.H., D.S. McCulloch, T.J. Conomos, and P.R. Carlson, 1972. Distribution of Lead and Copper in Surface Sediments in the San Francisco Bay Estuary, California, U.S. Geological Survey, Basic Data Contribution 36.

Samaniego, Robert, Water Resources Control Engineer, California Regional Water Quality Control Board, personal communication, 1982.

Shahid, Rafat, Director of Occupational Health/Hazardous Waste, Contra Costa County Health Services Department, personal communication, 1982.

Sittig, Marshall, 1980. Priority Toxic Pollutants, Health Impacts and Allowable Limits: New Jersey, Noyes Data Corp, 348 pp.

__________, 1981. Handbook of Toxic and Hazardous Chemicals: New Jersey, Noyes Publications, 719 pp.

U.S. Environmental Protection Agency (EPA), 1980. Controlling Hazardous Waste - Research Summary, EPA-600/8-80-017.

Chapter 4

WATER QUALITY OF CREEKS AND STORM DRAINS

Bessie Lee

Introduction

The East Bay creeks have been described as "natural virtues . . . furrowing their way through the canyons and pressing on toward the bay . . . " (Shipounoff, 1979, p. 11). In the East Bay there are several creeks that run through the cities of Albany, Berkeley, Emeryville, and Oakland. A list of Berkeley's creeks includes Cerrito Creek, Marin Creek, Codornices Creek, Schoolhouse Creek, Lincoln Creek, Strawberry Creek, Potter Creek, and several others (FIGURE 1).

To some of the residents of the East Bay, these waterways have brought much delight with their peaceful, identifiable sounds of rushing waters and with the feeling of being close to nature. However, as the years passed with the development of land areas and population growth in the East Bay, odor and health hazards became a problem. Creeks also have the potential to be polluted so that their natural beauty and forms of life within are destroyed. These waterways have caused much public concern over their water quality and their safety.

The purpose of this report is to study the water quality of the creeks and storm drains that flow into the East Bay shoreline and to investigate the major pollutants and the possible sources of contaminants. Water quality is an important aspect that affects recreational activities along the shore and should be considered in the East Bay Shoreline Park proposal. The focus will be directed to Berkeley's creeks, mainly Strawberry Creek which begins in the Berkeley hills and drains out at the foot of University Avenue. The report includes an evaluation of results of past bacterial contamination tests performed by public agencies and also a more recent bacterial contamination test performed by a few of the Environmental Sciences Seminar students (Aaron Jeung, Arthur Molseed, and Bessie Lee).

Water Quality Problems

Berkeley's creeks are not only a part of the city's natural drainage system, but they are also important as pathways for the removal of storm and spring water

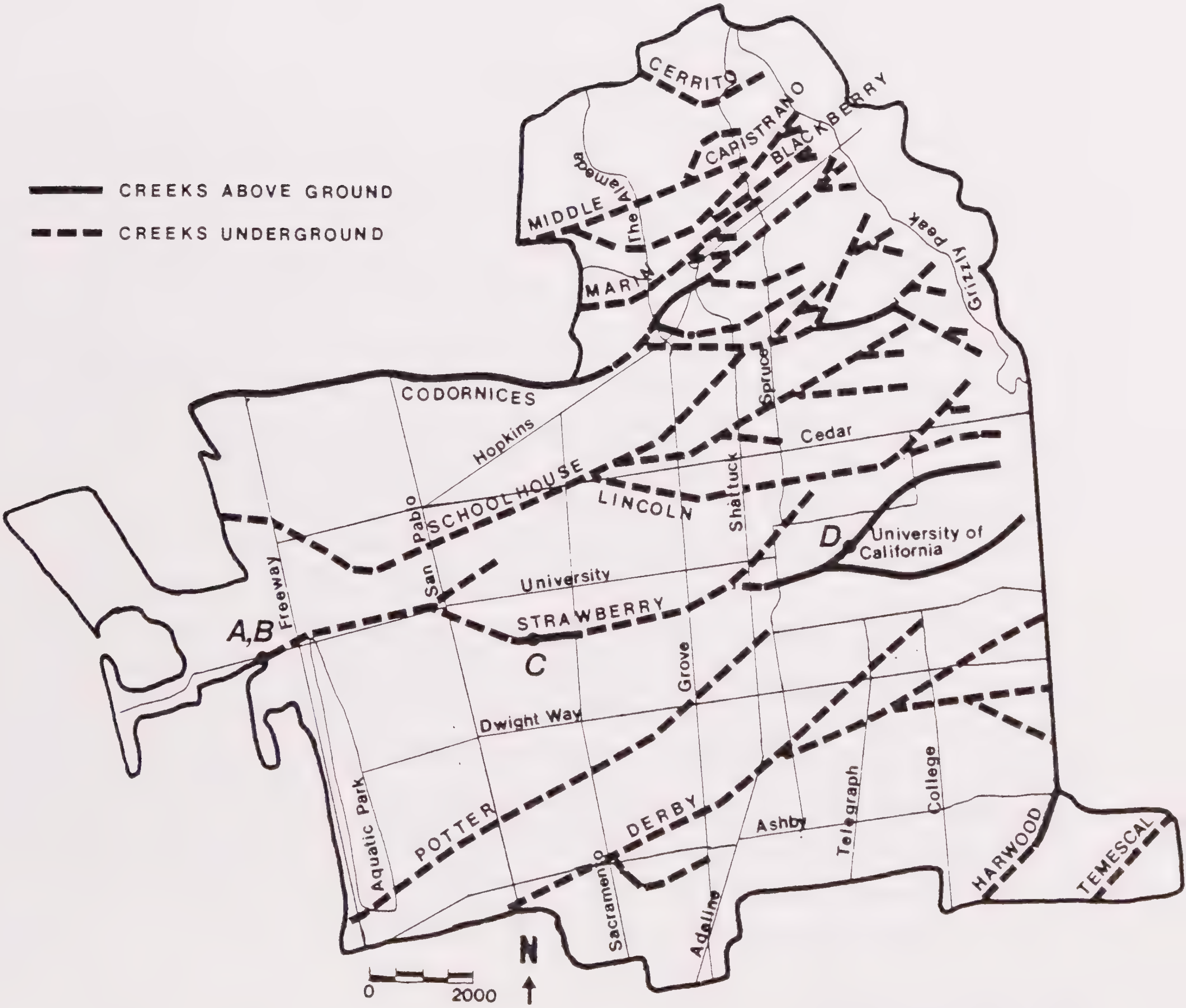


FIGURE 1. Creeks of Berkeley, Showing Locations Sampled.

Source: Master Plan Revision Committee, Berkeley Planning Department, 1975.

originating in the Berkeley hills area. Many of the city's storm water catch basins run into the creeks, which in turn run directly into the bay.

There is no doubt that the water in the creeks is contaminated to some degree. Contaminants first enter the picture as they are picked up by rain water as it passes through the atmosphere. These pollutants include oxides of sulfur and nitrogen and particulate matter. The precipitation then picks up additional material as it falls on streets, homes, industries, fields, lawns, and flows to a storm drain or nearby creek. These sources of pollution are called "non-point sources."

The main contaminants from non-point sources originate from surface runoff. The San Francisco Bay Area Environmental Management Plan (ABAG, 1978) identifies the surface runoff problems as:

1. Sedimentation and erosion
2. Bacterial contamination
3. Heavy metals, pesticides, and other toxic chemicals
4. Oil and grease
5. Litter and debris
6. Nutrients and algae growth
7. Organic wastes and low dissolved oxygen

After the identification of these major problems, it is then possible to recommend control measures to prevent these pollutants from occurring, as will be discussed later in this report.

Those sources of pollution which originate at specific locations are called "point sources." Examples of these include municipal wastes from sanitary sewers or inadequately treated sewage and industrial outfall. Point sources are easily recognizable sources of water pollution that pose a great threat to water quality. Through public willingness to allocate funds to protect water quality from point source pollution, this form of pollution has been greatly eliminated.

Pollutants that affect the East Bay shoreline include sediments, heavy metals, organic matter, algal nutrients, and bacteria. Sediments from erosion are a problem in that they tend to interfere with the drainage system and flood control systems. Heavy metals that originate from motor vehicles include lead, zinc, and copper. The source of organic matter and algal nutrients are believed to be from litter and vegetation. Because bacteria originating from animal feces and sanitary sewers are associated with health hazards and contamination of shellfish

(see Mirtha Ninayahuar's paper), they are an important concern.

Bacterial examinations are performed to detect contamination of water by sewage and thus eliminate the possibility that disease may be transmitted by its use. Contamination is determined by the total number of bacteria present and the presence or absence of common organisms of intestinal or feces origin. Among the most common organisms of the intestine or feces are the bacteria of the coliform group. Coliforms are constantly present in both healthy and diseased human intestines in large numbers. Thus, it is an advantage to use them as indicator organisms in testing for contamination. Another index organism for human and animal feces is fecal streptococcus. These bacteria are easily isolated from water and are frequently used as indices of fecal pollution.

<u>Past Studies of Water Quality</u>

In 1976, 1977, and 1978 sampling surveys of the Berkeley Marina and Strawberry Creek were conducted by the City of Berkeley Environmental Health Section (Gerber, 1978). The samples in the 1978 survey were collected after a rainy period occurring the previous day and weekend. The other surveys in 1976 and 1977 were conducted during periods of little or no surface runoff under dry or normal conditions.

Among the locations sampled were Potter Creek storm sewer outlet, the Strawberry Creek storm sewer outlet, and a few points on Strawberry Creek. Results showed high counts of coliform near these localities. The data indicated that the counts were high near the storm sewer outlets and that the counts decreased for the samples the farther away they were taken from the outlets. In all the years tested, Strawberry Creek samples showed extremely high coliform counts. The creek samples, #25 and #26, had Most Probable Numbers (MPN - an estimate of the number of index organisms per 100 ml) or at least 2,300. Such a high count is unsuitable for recreational activities.

Most of the samples taken on the date April 18, 1978 following a rainy period had higher counts of coliforms than samples collected in previous years at the same location. A comparison of these surveys under the different weather conditions shows that most coliform densities were greater during the increased surface runoff conditions. In 1978, seven of the twenty-five locations tested had fecal coliforms above the criterion of 200 fecal coliforms per 100 ml recommended for recreational waters (EPA, 1976). The previous sampling dates in 1977, December 1976, and July 1976 had five, three, and two locations, respectively, exceeding the criterion. The recreational water standard was always exceeded at the two sampling

locations on Strawberry Creek.

From the results of this survey, we can see that water quality should be of concern in considering the use of the shoreline areas near storm sewer outlets and the use of creeks. The possibility of health hazards occurring can be eliminated or minimized with proper attention towards water quality and safety.

Other studies of Strawberry Creek were conducted by the University of California in 1970, 1971, and 1972 (Herrera, 1970-1972). In these studies, samples were taken from both the north and south forks of the creek that runs through the campus. At various times the results showed coliform and fecal streptococci counts above 1,000. A 1977 study of the coliform count in Strawberry Creek under various weather conditions yielded the results given in TABLE 2. These samples were also taken at the University campus.

Methodology

The methods for routine detection and enumeration of coliforms and other indicator organisms are described by the American Public Health Association and affiliated societies (American Public Health Association, 1980). The technique used for our enumeration test is called the Most Probable Number (MPN) Method.

To test for coliforms, special media which enrich and select for certain bacteria are used. There are three parts to the standard coliform test, the presumptive test, the confirmed test and the completed test. The presumptive test consists of adding a known volume of the water sample into lauryl tryptose broth tubes and incubating for 24 $\pm$ 2 hours at 35°C $\pm$ 0.5°C. Presence of gas confirms the presumptive tests. If there is any doubt that the organisms present are coliforms, a completed test may be performed, and the organism examined microscopically to confirm. This test involves the use of eosin methylene blue agar. The normal extent of the coliform test consists of just the presumptive and confirmatory tests.

In order to estimate the number of coliforms in a sample, dilutions are made and inoculated into a series of tubes of media. The Most Probable Number can be determined by the distribution of positive tubes and determined by the use of tables in Standard Methods for the Examination of Water and Wastewater (American Public Health Association, 1980).

To determine fecal coliforms, a sample of all presumptive lactose tubes that showed a positive reaction are inoculated into *Escherichia coli* broth and placed in a waterbath for 24 $\pm$ 2 hours at 44.5°C $\pm$ 0.2°C. Production of gas in this medium

	Location	Total Colif. 4/18/78	Fecal Colif. 4/18/78	Total Colif. 8/25/77	Fecal Colif. 8/25/78	Total Colif. 12/14/76	Fecal Colif. 12/14/76	Total Colif. 7/1/76	Fecal Colif. 7/1/76
1	300 feet west from Potter St. storm sewer	24,000	500	<4.5	<4.5	230	<4.5	230	<4.5
2	400 feet west from Potter St.	6,200	620	<4.5	<4.5	230	<4.5	230	23
3	1500 feet north of Potter St. sewer	950	45	130	23	-	-	-	-
4	Opposite Aquatic Park near tidegate	60	<45	230	13	<4.5	<4.5	<4.5	<4.5
5	In a small bay, 100 of point 1,000 feet south of University Avenue storm sewer	60	<45	23	6	620	620	6	<4.5
6	600 feet west of University Ave. storm sewer outlet in small bay	6,200	1,300	1,300	500	500	60	62	6
7	800 feet west of University Ave. storm sewer outlet in small bay	620	<45	620	62	<4.5	<4.5	62	<4.5
8	1500 feet west of University Ave. storm sewer outlet in small bay	60	<45	230	230	230	<4.5	6	6
9	1800 feet west of University Ave. storm sewer outlet in small bay	<45	<45	23	23	60	<4.5	<4.5	<4.5
10	2400 feet west of University Ave. storm sewer outlet, 200 feet from proposed beach area	60	<45	<4.5	<4.5	<4.5	<4.5	<4.5	<4.5
11	100 feet out from small point 2500 feet west of University Ave. storm sewer outlet	620	60	<4.5	<4.5	230	<4.5	<4.5	<4.5
12	400 feet out from small point 2600 feet west of University Ave. storm sewer outlet	230	<45	6	6	230	<4.5	6	<4.5
13	500 feet out from small point 2700 feet west of University Ave. storm sewer outlet	230	60	23	23	60	<4.5	6	<4.5
14	100 feet east of small point (H's Lordships)	60	60	13	6	<4.5	<4.5	<4.5	<4.5
15	100 feet south of pier	620	<45	230	230	<4.5	<4.5	6	<4.5
16	South edge of breakwater	620	620	23	23	60	<4.5	6	<4.5

(continued)

	Location	Total Colif. 4/18/78	Fecal Colif. 4/18/78	Total Colif. 8/25/77	Fecal Colif. 8/25/77	Total Colif. 12/14/76	Fecal Colif. 12/14/76	Total Colif. 7/1/76	Fecal Colif. 7/1/76
17	200 feet north of Dike Point	620	620	<4.5	<4.5	<4.5	<4.5	12	<4.5
18	East of dump area (lagoon)	620	60	6	<4.5	-	-	-	-
19	South end of lagoon	620	60	-	-	-	-	-	-
20	East side of lagoon	230	<45	-	-	-	-	-	-
21	Center of lagoon	230	<45	-	-	-	-	-	-
22	Middle of Marina	230	<45	23	<4.5	230	<4.5	230	23
23	South edge of Marina	230	<45	620	6	60	<4.5	23	6
24	Opposite of dump entrance	-	-	50	12	230	60	62	23
25	Strawberry Creek near Strawberry Creek Lodge	23,000	6,200	≥24,000	7,000	23,000	500	70,000	6,200
26	Strawberry Creek near Oxford Street	62,000	2,300	≥24,000	7,000	23,000	6,200	13,000	2,300

TABLE 1. Marina and Strawberry Creek Water Quality Survey.
Source: Gerber, 1978.

indicates the presence of coliforms of fecal origin. An MPN based upon positive Escherichia coli broth tubes represents the fecal coliform number.

The enumeration of fecal streptococci in a sample involves inoculating dilutions of test samples into azide dextrose broth. These tubes are incubated for 24 $\pm$ hours at 35°C $\pm$ 0.5°C. Tubes that show no definite turbidity are reincubated and read again at the end of 48 $\pm$ 3 hours. Growth in the tube as indicated by turbidity, is considered a positive presumptive test. The next step calls for streaking a portion of growth from each positive azide dextrose broth tube onto a petri dish containing Pfizer selective enterococcus agar. The inverted dish is then incubated at 24 $\pm$ 2 hours at 35°C $\pm$ 0.5°C. Brownish-black colonies with brown halos will indicate the presence of fecal streptococci. An MPN based upon positive plates represents the fecal streptococci number.

Sampling Survey of Strawberry Creek

The water samples for the bacteriological tests were taken on the morning of April 19, 1982, a warm and sunny day. The last rainfall occurred two days prior to the sampling date.

	MPN/100 ml		
	TOTAL COLIFORMS		
LOCATION	8/24/77 warm and sunny	9/12/77 warm and overcast	9/19/77 two days after rainfall
South fork of Strawberry Creek	540	920	540
Near the bridge in front of Giannini Hall	130	920	350

TABLE 2. 1977 Study of Strawberry Creek.

Source: University of California, Berkeley, Office of Environmental Health and Safety.

Many thanks are given to David Gan of the California Department of Health Services for his guidance through the performance of the test and to the Department for allowing us to use the laboratory facilities and supplying the necessary equipment and materials.

The locations selected for our sampling survey were as follows (FIGURE 1):

SAMPLE A	Strawberry Creek storm sewer outlet
SAMPLE B	Strawberry Creek storm sewer outlet
SAMPLE C	Residential/Industrial Near Allston Way and West Street
SAMPLE D	University of California, Berkeley campus Near bridge by Giannini Hall

The results of this survey are shown on TABLE 3. The last column of the table indicates the Fecal Coliform/Fecal Streptococci ratio calculated from the results. This ratio gives an indication of the origin of the fecal material. When the ratio is greater than or equal to 4, it may be taken as evidence that pollution originated from human fecal contamination (American Public Health Association, 1980). Since our ratios were less than 1, the water samples probably contained bacteria from the wastes of animals.

Discussion of Water Quality Studies

The U.S. Environmental Protection Agency's criterion for water quality for recreational waters is as follows:

Based on a minimum of five samples taken over a 30-day period, the fecal coliform bacteria should not exceed a log mean of 200 per 100 ml, nor should more than 10 percent of the total samples taken during any 30-day period exceed 400 per 100 ml. (EPA, 1976)

The amount of surface runoff affects the bacterial density in the water. The surface runoff from precipitation that occurs after a long dry period would tend to contain more contaminants than the surface runoff that follows several days of rainfall.

	MPN/100 ml			
SAMPLE	TOTAL COLIFORM	FECAL COLIFORM	FECAL STREPTOCOCCI	FECAL COLIFORM/ FECAL STREPTOCOCCI RATIO
A	16,000	1,300	5,400	1
B	9,200	1,100	3,500	1
C	3,500	1,100	3,500	1
D	3,500	1,300	5,400	1

TABLE 3. 1982 Study of Strawberry Creek.

The results of our sampling survey of Strawberry Creek indicate that fecal coliform bacteria counts greatly exceed the limit of 200 per 100 ml. The source of the bacterial pollution is probably due to warm-blooded animals other than man.

The analysis of the past water quality studies and our own bacteriological study indicates that the water in the creeks and storm drains has been contaminated with fecal pollution. The studies also show that the different coliform counts were not attributable to the weather conditions or increased surface runoff. These conclusions indicate strongly the need to consider water quality safety factors in the proposal of recreational uses of the creeks and the East Bay shoreline.

Pollution Prevention Recommendations

Because of the high costs of treatment and the lack of facilities to handle the additional load during runoff surges, water from the creeks and storm drains go untreated directly into the bay.

A method to reduce bacterial contamination of the creeks and the shoreline involves the proper disposal of domestic animal wastes. Another possibility is to construct a sand filter at the storm sewer outfall. The sand filter would be similar to the filter at sewage treatment plants with a top layer of activated carbon. The layers absorb bacteria and also absorb pesticides and other contaminants. The difficulties involved with the sand filter are its cost and the frequent need of backwashing (Singh, personal communication, 1982).

In addition to bacterial contamination as a pollutant, there are other pollutants not discussed in this paper that may also be a major concern. An effective solution to reduce the amount of pollutants going out to the bay is through public awareness. Controlling litter through anti-litter programs and educating the public on the water quality impacts of litter would reduce the amount of debris and oil, thereby reducing BOD, phosphates, suspended solids, and heavy metals introduced through the stormwater system.

An example of a much-needed awareness program is one to educate the public about the benefits of oil recycling, the ease of recycling, and the consequences of dumping oil into the sewers or storm drains. Among the benefits of oil recycling are reducing the incidence of odors associated with decomposing debris, enhancing water-oriented recreational potential where dumping of debris and oil impairs the use, and improving visual characteristics (ABAG, 1978).

In the past, Berkeley's Department of Public Works handled the issue of public awareness by distributing through the mail a notice to residents concerning the water quality and safety of the water which flows in the creeks (Jackson, pers. comm., 1982). It stressed the possibility of harmful organisms and toxic chemicals in the water and explained how everyone can help keep the creeks clean by not disposing of any waste directly into the creeks or through the storm drain system.

Another measure is to enforce the prohibition against dumping or discharging pollutants into the storm drains and creeks. The Berkeley Municipal Code states that it is unlawful for "any person to place, throw or deposit or cause or permit to be placed, thrown or deposited in any public sewer, drain, catch basin, privy, vault or cesspool or in any vessel or receptacle connected to any public sewer, any dead animal, fish, offal or garbage, hair, ashes, cinders, wastes, gasoline, distillate, lubricating oil, grease, . . . " (Berkeley Municipal Code, 1976, pp. 398-397).

Another measure to reduce the surface runoff pollutants includes the increased use and improvement of existing street sweeping. In the City of Berkeley, streets

are usually cleaned daily in commercial areas and only by priority or request in residential areas due to the lack of manpower (Jackson, pers. comm., 1982). Exceptions are those areas which are highly populated with parked cars (e.g., streets near the University of California campus). Concentrating street sweeping prior to the rainy season, revising the street sweeping schedule to emphasize leaf pickups during fall and winter, and imposing parking restrictions to allow sweeper access to curb areas are approaches to reducing surface runoff.

Reducing pollution by cleaning the stormwater collection system is another measure. This involves a more frequent cleaning of the catch-basins, storm drains and open channels to remove all the material collected from contaminating runoff which should improve water quality and flood control. In the City of Berkeley, catch-basins are cleaned but once a year (Jackson, pers. comm., 1982).

By the education of the general public on the proper use and disposal of hazardous chemicals and regulating the use of certain chemicals (e.g., vector control chemicals and pesticides), health and safety risks should be reduce.

With the establishment of a water quality monitoring program, causes of specific problems can be identified and lead to reduction or elimination. This measure would insure proper operation of septic tanks and sewage pipes by identifying leaks and overflows.

These pollution prevention measures all involve some public participation and awareness and with these, the creeks and the bay would provide a safe and pleasing environment for us all.

REFERENCES CITED

American Public Health Association, 1980. Standard Methods for the Examination of Water and Wastewater, 15th Edition, 1134 pp.

Association of Bay Area Governments (ABAG), 1978. San Francisco Bay Area Environmental Management Plan, Appendix C, Draft County Surface Runoff Plans, Regional Summary and Alameda County Plan.

Berkeley Municipal Code, 1976, 604 pp.

City of Berkeley Master Plan, 1977, 204 pp.

Gan, David, Public Health Chemist, California Department of Health Services. Personal Communication, April 1982.

Gerber, Martin J., 1978. Unpublished data. Marina and Strawberry Creek Water Quality Survey, for City of Berkeley, Environmental Health Section.

Herrera, Josefina R., 1970-1972, 1977. Unpublished data on Strawberry Creek, for U.C. Berkeley, Environmental Health and Safety.

__________, Associate Technologist, University of California, Berkeley, Office of Environmental Health and Safety. Personal communication, March 1982.

(continued)

Jackson, Sherman, Maintenance Supervisor, City of Berkeley, Public Works Department. Personal communication, March 1982.

Sartor, James D. and Gail B. Boyd, 1972. Water Pollution Aspects of Street Surface Contaminants. Environmental Protection Agency R2-72-081. Washington, D.C., 236 pp.

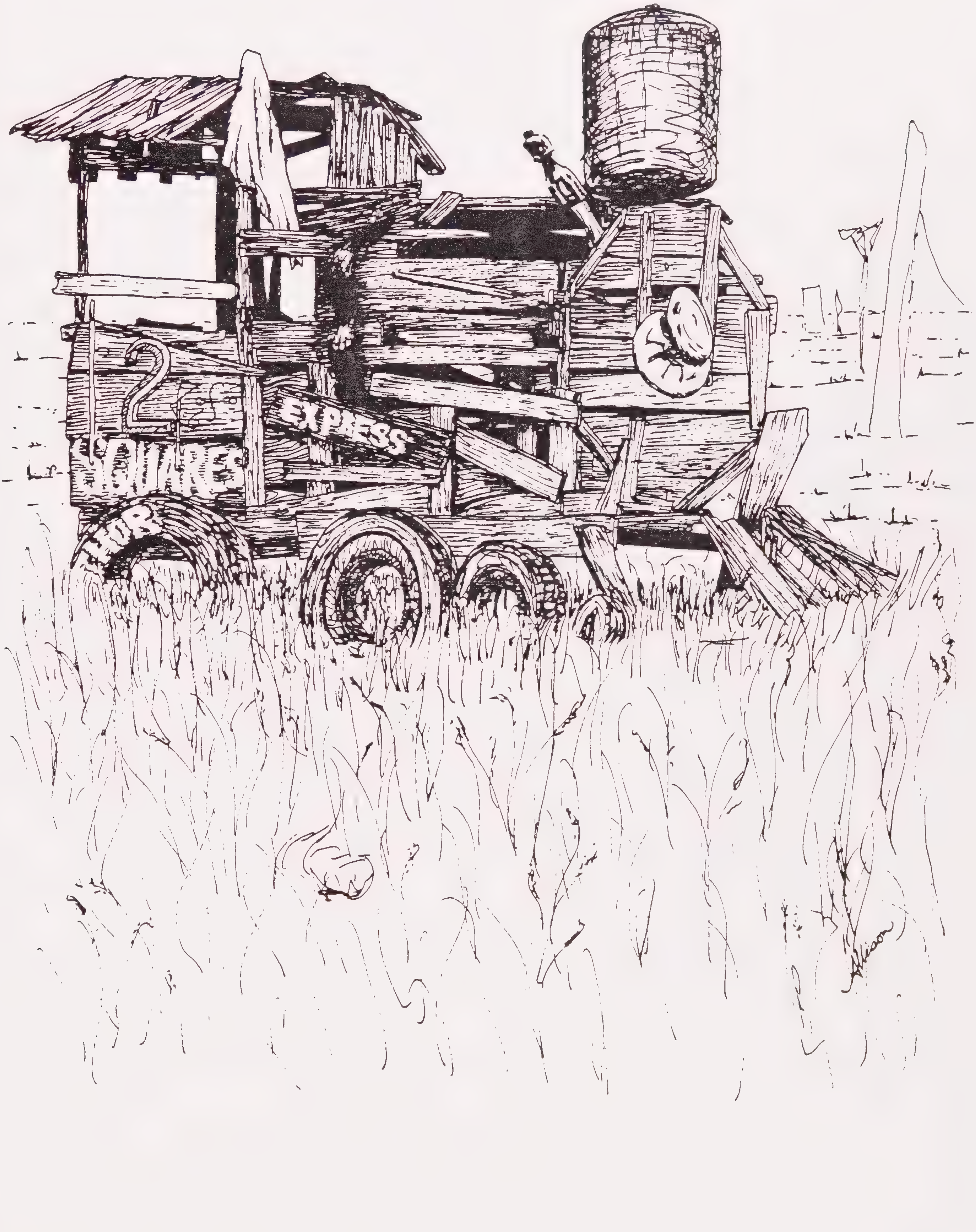
Shipounoff, Dimitri, 1979. Trout Fishing in the Berkeley Hills: Berkeley Monthly, v. 10, no. 2, pp. 11-13.

Singh, Sher, Associate Environmental Engineer, East Bay Municipal Utilities District. Personal communication, May 1982.

Spencer, Vince, Registered Sanitarian, City of Berkeley, Environmental Health Section. Personal communication, February - March 1982.

U.S. Environmental Protection Agency (EPA), 1976. Quality Criteria for Water. Washington, D.C., 256 pp.

SECTION IV: SITE STUDIES ALONG THE SHORELINE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EXPRESS

Chapter 1

THE SALT MARSH HARVEST MOUSE IN THE EMERYVILLE CRESCENT MARSH

David Olson

The East Bay shoreline from the Bay Bridge approach in Emeryville northwards to the Richmond city limits (see map, p. vi) is currently under consideration for some form of development program. The present study is directed toward determining the status of the salt marsh harvest mouse, Reithrodontomys raviventris, within this area in the hope that it will aid in rational decisions for future programs and add to the available information on the species.

The salt marsh harvest mouse (SMHM) is an unusual mammal endemic to the salt marshes of the San Francisco Bay region. It is physiologically and behaviorally adapted to the rigorous conditions of the salt marsh environment. The species has the ability to tolerate high salt concentrations, which allows it to subsist on saltwater and saline marsh vegetation (Fisler, 1965). The SMHM has also adapted to tidal fluctuations through its strong swimming ability and non-aggressive behavior towards its own species while crowded on marsh patches above high tides (Fisler, 1965). A subspecies of R. raviventris, R. r. halicoetes, inhabits more brackish marshes in San Pablo and Suisun Bays, while the former is confined to salt marshes in San Francisco Bay proper (FIGURE 1).

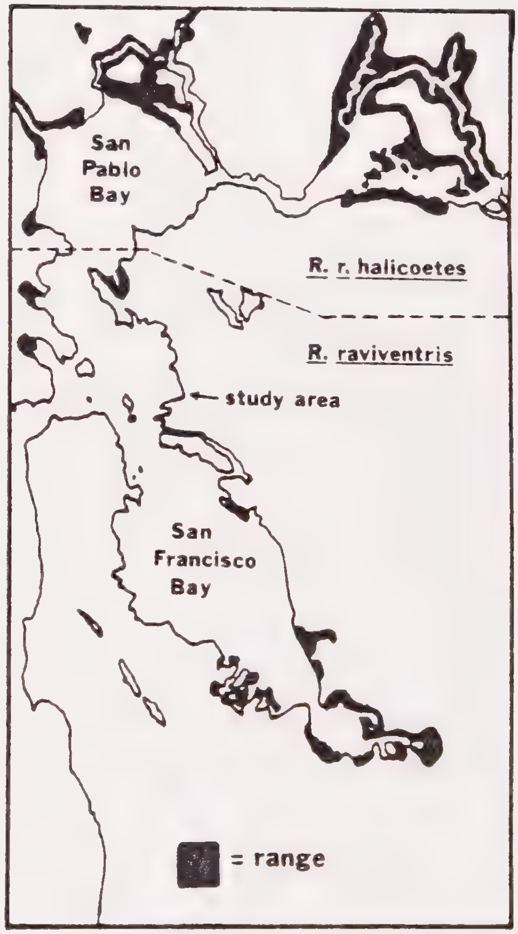

FIGURE 1. Present distribution of the Salt Marsh Harvest Mouse in the San Francisco Bay region. Adapted from Fradkin, 1979.

The SMHM is presently on both the federal and state of California list of endangered species. It is considered endangered because much of its naturally restricted habitat has been

altered or destroyed, and it has been reduced to small disjunct populations throughout its range. The disappearance of nearly sixty percent of the original marshlands of the bay has resulted primarily from human activity such as filling, diking, and water pollution (Fradkin, 1977). The southern subspecies, R. raviventris, is considered the most threatened, since development has been heaviest in the central and southern portions of the bay. R. raviventris ranged throughout the salt marshes which originally encircled much of San Francisco Bay (Fisler, 1965). Although data on its present distribution are incomplete, there are recognized populations in relatively undisturbed marshland at Corte Madera, San Pablo Creek, South Oakland and San Leandro area, the Dumbarton and Alviso marsh complex, and the Palo Alto-Redwood City marshes (Fisler, 1965).

The East Bay shoreline has two substantial salt marshes, the Hoffman Marsh and the Emeryville Crescent Marsh (see map, p. vi). The Hoffman Marsh is enclosed by earth fill except for canals on its east and west sides. Tidal channels weave through an established covering of pickleweed, Salicornia. Smaller patches of marsh, some open to the bay, occur to the northwest. The accompanying report by Mark Oddi describes the Hoffman Marsh area in detail. The Emeryville Crescent Marsh fringes the L-shaped shoreline between the Emeryville Marina spit and Bay Bridge toll plaza. The present SMHM survey was conducted solely in this area because, in comparison to the Hoffman Marsh, it contains the most favorable SMHM habitat, would be most affected by current development proposals, and, in light of conservation goals, has a greater wildlife value in terms of species and habitat diversity. In addition, this area has no record of previous SMHM surveys, although the species' presence is assumed (Bodega Bay Institute, 1978). Two previous SMHM surveys in the Hoffman Marsh are described in detail in the discussion of local distribution.

Description of Survey Area

Salt marsh vegetation displays a zonation pattern which is directly related to the tolerance of each species to water and saline conditions (Bodega Bay Institute, 1978). Cordgrass, Spartina foliosa, tolerates regular tidal submersion where it grows along the water's edge. Pickleweed, Salicornia, a succulent-stemmed halophyte, occurs in the intermediate zone, often in extensive pure stands (Fisler, 1965). The higher areas are characterized by gumplant, Grindelia cuneifolia, which is interspersed with lower growing species such as saltgrass (Distichlis spicata), iceplant (Mesembryantheum), and sea lavender (Limonium californicum). Local topography and tidal height influence the amount of gradation between zones (Fisler, 1965).

Five distinct areas of the Emeryville Crescent Marsh are recognized: the northern and southern halves of the Sculpture Marsh, the Shellmound Marsh, the Neck, and the Duck Club Marsh (Bodega Bay Institute, 1978; FIGURE 2). The Sculpture Marsh borders Interstate 80 and is bisected by the Temescal Creek outfall. Two spits around the mouth of the creek extend outward into the bay and are covered with upland vegetation. This vegetation type, which includes gumplant, coyotebush, arroyo willow, and a variety of herbaceous plants and grasses, also occurs between the pickleweed zone and the highway. The Salicornia zone averages 100 meters wide in the northern section. The construction of driftwood sculptures here has created an extensive trampled area with pools of standing water between the upland and Salicornia zones. Sculptures extend into the Southern Sculpture Marsh for nearly three-fourths of its length. Past the sculptures, the Salicornia zone widens to roughly 175 meters.

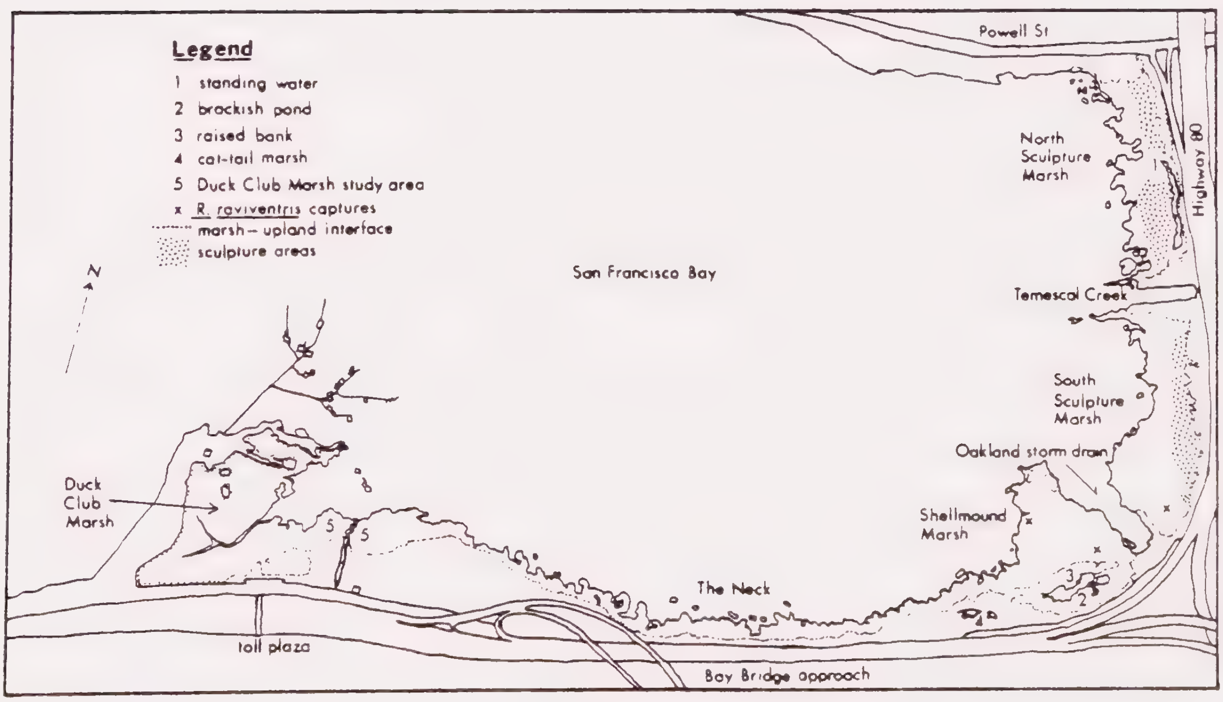

FIGURE 2. The Emeryville Crescent Marsh.
Adapted from an aerial photograph, SFB-38-14, 6/17/80, Army Corps of Engineers.

The Shellmound Marsh lies westward from the Oakland Storm Drain to the narrow portion of the marsh known as the Neck. Extensive stands of _Salicornia_ of varied height and condition grow in the Shellmound Marsh. A raised sandy bank, running parallel to the bay across the _Salicornia_ zone, supports _Grindelia_ and associated plants. Tall stands of _Salicornia_, a brackish pond, and a cattail marsh lie between this bank and the upland vegetation bordering the highway. Stands of _Spartina_ predominate in the Neck. The Duck Club Marsh, lying in the embayment formed by the Duck Club Spit, is largely a mixture of cordgrass and pickleweed and appears to be flooded frequently by tides.

The wide _Salicornia_ zone at the southern end of the South Sculpture Marsh was surveyed for SMHM. In the Shellmound Marsh, the raised bank and stands of _Salicornia_ on either side were surveyed, and higher areas supporting _Grindelia_ and thick _Salicornia_ along the outer edge toward the bay were also trapped. Two patches of relatively pure _Salticornia_ along the southeastern edge of the Duck Club Marsh were surveyed. These areas were chosen because of their relatively large stands of pure _Salicornia_ and dense upland vegetation, features considered favorable for SMHM.

Methods

The main goal of the live-trapping survey was to determine the presence of the salt marsh harvest mouse. Population parameters such as size, density, and age structure were not evaluated because of two assumptions about the species' behavior. First, the decreased activity of the SMHM during the colder winter months may affect capture success and population analysis (Dr. Howard Shellhammer, pers. corr., 1982). Second, density estimates would be complicated by the winter movement of SMHM populations to higher areas in the marsh as a reaction to the season's extreme high tides (Johnston, 1957).

Trapping was carried out between February 12 and March 3. Medium-sized Sherman live traps, 3" x 3" x 9", were used throughout the survey. The treadles were adjusted to release when the traps were lightly tapped. Bait was a mixture of wild bird seed and rolled oats. Walnut extract was applied to each trap entrance as an attractant. Cotton was provided for nesting material and warmth.

The positioning of trap lines varied with the characteristics of each site. An effort was made to place traps above nocturnal high tide levels to avoid drowning captures. Trap lines consisted of a straight series of thirty traps spaced at intervals of approximately 8 to 10 meters. Sixty traps were set each night. Captures were not marked and only one trap-related death occurred, that of a house mouse.

The following measurements and observations of captures were recorded: body length, tail length, ear length, hind foot length, tail to body ratio, diameter of tail 2 cm from body, sex, reproductive status, tail shape and coloration, body coloration, activity, and a habitat description of the trap locality.

Results

Ten house mice, *Mus musculus*, and two rats were caught in the Duck Club Marsh after two trap nights (TABLE 1). Three trap nights in the South Sculpture Marsh resulted in the capture of 22 house mice, 1 California vole, *Microtus californicus*, and 1 *R. raviventris*. The SMHM, a male, was captured in tall *Salicornia* averaging 34 cm that was roughly twenty meters from upland vegetation. Trap lines were set in the Shellmound Marsh for four nights. Capture results totaled 27 house mice, 4 voles, and 2 *R. raviventris*. A mature male was captured in *Salicornia* averaging 30 cm in height that was 25 meters from the raised sandy bank. Another male was captured in tall, thick *Salicornia*, averaging 42 cm, that was roughly 135 meters from the raised bank. The trap was located 4 meters from a *Spartina*-lined tidal inlet at the bay's edge. The low SMHM capture success of this study is attributed to the species' decreased activity during winter and the small number of traps used.) Measurements and observations of captured SMHM are given in TABLE 2).

Discussion

The salt marsh harvest mouse is the only rodent able to spend its entire life within the salt marsh environment. The fibrous material from pickleweed and other marsh vegetation compose the bulk of its diet; seeds and grasses are eaten to a lesser extent. Tall, thick *Salicornia*, which is submerged by the highest tides, is considered optimal habitat for *R. raviventris* (Wondellock *et al*., 1976). The species commonly occurs throughout *Salicornia* stands, but generally avoids *Spartina* and *Spartina*-*Salicornia* mixtures, which offer less cover and are flooded daily by tides (Fisler, 1965). Fisler (1965) observed *R. raviventris* venturing into the marsh-grassland interface during the spring. The mice are seldom found away from thick vegetative cover, which provides protection from predators such as owls, hawks, egrets, and herons (Fisler, 1965). The partially diurnal activity of *R. raviventris*, which increases its exposure to predators, emphasizes the importance of cover Fisler, 1965).

Table 1 Capture results, live trapping survey in the Emeryville Crescent Marsh, 1982.

	Duck Club Marsh			Shellmound Marsh					S. Sculpture Marsh			
	2/25	3/8	Total	2/12	2/17	2/23	2/27	Total	2/18	2/22	3/3	Total
house mice, *Mus musculus*	8	2	10	3	12	5	7	27	4	7	11	22
voles, *Microtus*	0	0	0	2	0	0	2	4	0	0	4	4
rat, unidentif.	2	0	2	0	0	0	0	0	0	0	0	0
R. raviventris	0	0	0	0	0	1	1	2	0	1	0	1

Table 2 Measurements and observations of captured R. raviventris in the Emeryville Crescent Marsh, 1982.

	S. Sculpture Marsh 2/22	Shellmound Marsh 2/23	2/27
body length	7.5 cm	6.4 cm	6.4 cm
tail length	7.8 cm	7.3 cm	7.4 cm
tail/body ratio	1.04	1.14	1.16
hind foot length	1.6 cm	1.4 cm	1.4 cm
ear length	0.9 cm	0.9 cm	0.7 cm
tip of tail	blunt	blunt	blunt
tail pattern	unicolor	unicolor	unicolor
tail hairs	no white hairs	no white hairs	no white hairs
behavior	placid	placid	placid
diameter of tail 2 mm from body	2.8 mm	2.7 mm	2.7 mm
sex	male	male	male
testes	desc.	desc.	desc.
venter coloration	grayish white cinnamon on edges	grayish white	grayish white
comments	- trap 20 meters from upland veg. - in tall *Salicornia* averaging 34 cm	-trap 25 meters from upland vegetation -in tall *Salicornia* averaging 30 cm -dark upper body and ears	- trap 200 meters from upland vegetation - trap 4 meters from bays edge - in tall *Salicoria* averag. 42 cm - dark upper body and ears

Populations apparently congregate towards the higher areas of the marsh during the winter as a response to extreme high tides (Fisler, 1965). Dense vegetative cover along the upper edges of the marsh acts as an important refuge during the extreme high tides. Destruction of upland marsh vegetation is a significant factor in the displacement of SMHM populations. Fisler (1965) cites examples of this situation occurring in marshes south of San Rafael. His study is recommended as a thorough discussion of the ecology, taxonomy, and physiology of the *Reithrodontomys* of the Bay Area. Zetterquist (1977) reports the presence of *R. raviventris* in marginal habitats such as diked marshes and cattails. This study may have significant impact on current views of SMHM ecology and management, and expand the definition of predictable SMHM habitat. It merits further investigation.

Mortality factors include predation, drowning, winter chill, and water pollution. The decline in habitat may lead to the extinction of isolated populations whose numbers fall below the threshold level. Furthermore, small disjunct populations may tend toward inbreeding, limitations on the gene pool, and genetic random drift. These traits are deleterious to the population's adaptive potential and eventual survival (Zetterquist, 1977).

Local Distribution

The areas where *R. raviventris* was captured in the Emeryville Crescent, the Shellmound Marsh and the South Sculpture Marsh, contain favorable SMHM habitat. Each has large stands of *Salicornia* that are tall and dense in places. In addition, there is substantial vegetative cover along the upper edges of both areas. This is a critical feature to be looked for when evaluating the suitability of a habitat for SMHM. It is possible that *R. raviventris* inhabits the Duck Club Marsh, although it was not trapped. It would probably be restricted to the purer stands of *Salicornia* along the southeastern edge and surrounding utility pole islands in the middle of the marsh. These areas are bordered by thick upland vegetation. Much of this marsh appears to be too wet and lacking in upland cover to be good habitat for SMHM. It is unlikely that resident populations exist in the sparse patches of *Salicornia* found in the Neck. The sculpture areas of the Sculpture Marsh have sustained such extensive damage to the upper *Salicornia* zone and upland vegetation that resident SMHM populations are improbable. Trampling of vegetation destroys protective cover and critical upland refuges.

This distribution analysis is based on areas having optimal habitat features, but does not preclude the possibility that the SMHM may utilize less favorable

areas. The dispersal of mice throughout the marsh during the summer months, as reported by Fisler (1965), may occur within the study area. For example, wetter stands of Salicornia in the Duck Club Marsh and Salicornia areas behind the trampled sculpture sites may be frequented by nearby resident populations.

The other major marsh complex along the East Bay shoreline is the Hoffman Marsh (see map, p. vi; refer to the report by Mark Oddi, which investigates this area). No SMHM were found in two previous surveys of the Hoffman Marsh. A survey by the URS Research Company for Caltrans consisted of 150 trap-nights over 15 acres of shoreline vegetation (1972). Further procedural details are not given. There were no SMHM captured. The URS report did assume, however, that the SMHM inhabited the marsh because of suitable habitat and proximity to known SMHM localities to the north. The California Department of Fish and Game also surveyed the Hoffman Marsh and a narrow marsh channel to the northwest over three 46 trap-nights in June, 1978. None of the endangered species were found.

As part of this study, the Hoffman Marsh was surveyed for suitable SMHM habitat. The Salicornia covering the Hoffman Marsh is generally short-to-medium height and rarely dense. Dense upland vegetation is found only along the north and west sides and atop a raised levee running across the southern section of the Hoffman Marsh. Two marshes are located to the northwest on both sides of a railroad track levee. The marsh fringing the bay side is relatively wet but could develop into suitable SMHM habitat. The marsh on the other side of the tracks, referred to as the University Marsh in Mark Oddi's report, contains some dense pickleweed and thick upland vegetation on the eastern edge. This Salicornia stand and western portions of the Hoffman Marsh appear to have the most suitable SMHM habitat in the area. Additional surveys are needed to establish the status of the species in these areas.

Habitat Destruction

The sensitivity of the salt marsh environment has helped hasten its rapid decline in the San Francisco Bay region. Several processes altering SMHM habitat are presently occurring, or have the potential to occur, within the Emeryville Crescent Marsh. A visibly severe problem in the Crescent is the trampling of marsh vegetation by sculpture builders, sightseers, and birdwatchers. Pickleweed is extremely sensitive to trampling and regenerates very slowly (Bodega Bay Institute, 1978). Sculpture buildres can completely destroy the Salicornia surrounding their work in a matter of hours (Stephen Bailey, pers. corr., 1982). Moreover, marsh soils are readily compacted. Severe trampling can create a 'hardpan' surface

which resists recolonization by marsh vegetation, increases soil salinity, and decreases soil moisture (Bodega Bay Institute, 1978; see also paper by James Doyle). Trampled openings in the marsh vegetation eliminate protective cover and inhibit movement of the SMHM between the marsh and upland refuges. Sculpture builders presently cause the most trampling damage. Presumably, birdwatchers and hikers would tend to remain on the few rough trails that border the marsh. A California Highway Patrol officer related that he had observed up to twenty 'sightseers' in the marsh at one time, many of whom were illegally, and dangerously, parked along Highway 80.

Factors of vegetational change can alter SMHM habitat. Successional domination by Spartina can result from marsh subsidence; conversely, the Salicornia zone can be taken over by upland vegetation and grasses as sediment deposition occurs (Dr. Howard Shellhammer, pers. corr., 1982). The nature of vegetational change that might be caused by increasing freshwater discharge from Temescal Creek and the Oakland Storm Drain, and chemical pollution from these outfalls and the bay is not precisely known.

No studies concerning the displacement of R. raviventris by introduced species were located. The only small mammal that was found in substantial numbers in the Salicornia zone was the common house mouse. Schaub (1972) found large numbers of Mus present at established SMHM localities. Therefore, it is unlikely that Mus populations will significantly threaten the SMHM in the Emeryville Crescent.

Effects of Development

The viability of the Emeryville Crescent as a salt marsh harvest mouse habitat could be significantly altered by proposed commercial and recreational developments. The Golden Gate Audubon Society's publication, The Crescent (Bodega Bay Institute, 1978), is recommended for a thorough environmental assessment of some major proposals.

Santa Fe Land, Inc. presently owns the marsh and the feasibility of any project is dependent upon mitigation by them. The North Harbor site of the Port of Oakland is considered as a potential port terminal site in the Port of Oakland Shoreline Plan (1968) and by the Metropolitan Transportation Commission (Bodega Bay Institute, 1978). The facility would extend roughly 2/3 of a mile westwards from the western edge of the Duck Club Marsh. The large fill required for this project would decrease tidal flushing to the marsh. Additional marsh impacts from this facility would probably include increased human disturbance, turbidity of surrounding water, debris and chemical pollution, and acceleration of marsh sedimentation (Bodega Bay Institute, 1978). Essentially, any commercial or recreational

developments in the Crescent or adjacent areas would have deleterious effects on SMHM populations through such actions as filling, grading, pollution, and vegetation change induced by sedimentation.

Proposals for recreational development in the Crescent may conflict with preservational goals for the marsh and its associated wildlife. The East Bay Regional Park District (EBRPD) Master Plan - 1980 proposes a bicycle-pedestrian pathway to be constructed along the Emeryville Crescent as part of a regional shoreline trail (EBRPD, 1980, p. 21). Approximately 1.5 miles of Crescent marshlands and upland habitat are in the projected pathway. The trail, since it passes through a Caltrans right-of-way, has been classified as a Class I Bikeway and must meet certain specifications. A minimum 8-foot paved section within a 14-foot graded area is required and a 30-foot fenced buffer zone is recommended between the trail and the highway (Bodega Bay Institute, 1978). Construction of this trail is likely to result in increased trampling from heavy equipment and workmen, mechanical destruction of marsh and upland vegetation, increased sedimentation and erosion from grading and fill, and the creation of a barrier between the Salicornia zone and the upland refuges used by the SMHM. Greater human activity in the marsh, as a result of the trail, would likely increase trampling damage. Proposed moats and fences designed to prohibit this intrusion would also destroy marsh vegetation, alter natural sedimentation and drainage, and create barriers between the upland and marsh zones (Bodega Bay Institute, 1978). These factors suggest that the construction of the proposed bikepath would have significant adverse effects on R. raviventris habitat.

The Crescent is recognized as containing sensitive natural habitat with important wildlife value. Several proposals would maintain the salt marsh and increase public access in a manner less damaging than the bike trail. Some representatives of local and state agencies concerned with the Crescent's future contend that any projected land use plan should increase access and benefit the general public in order to gain public and financial support. Peter Koos of EBRPD feels that increasing the public's awareness of the Crescent's value through controlled access will eventually help eliminate activities in conflict with preserving the area. Public access should be restricted to the upland-marsh interface and be properly controlled to minimize the damage that it may cause.

The establishment of an interpretive boardwalk through the marsh may produce several detrimental effects on SMHM habitat. Construction of the boardwalk could

alter the marsh in a manner similar to the proposed bikepath construction. Wildlife in the marsh can be disturbed by dogs and humans on the boardwalk. Dogs and people leaving the walkway could destroy marsh vegetation and prey upon wildlife. If this project is implemented, several measures should be taken to minimize damage to the marsh. These include delicate and conscientious construction of the board-walk on raised piles, railing to contain visitors, prohibiting dogs, interpretive and regulatory signs, and a full-time 'ranger' with adequate policing authority.

A more favorable option for preserving the SMHS habitat would be the location of interpretive centers and observation platforms at the Duck Club Marsh and Northern Sculpture Marsh. These platforms would be located in upland areas and not in the marsh directly. These would increase public awareness of this natural resource and help validate the need for a full-time 'ranger' to monitor activities. Adequate fencing along the highway and at either end of the crescent is suggested to help preserve the salt marsh.

It is further suggested that human activity in the sculpture area be curtailed, especially in the Southern Sculpture Marsh. If a sculpture area must be maintained, it should be limited to the Northern Sculpture Marsh, as this would not likely affect the survival of the SMHM in the Crescent.

If present forms of use of the marsh continue they will have adverse results. Informal and unrestricted uses of the marsh, such as sculpture building, will continue to increase and eventually cause extensive damage. Furthermore, implementation of official conservation goals in the Crescent would preclude any adverse development options. It must be emphasized that the balancing of political, economic, social, and scientific interests in this issue is a delicate process with many complex variables. Many public and private groups have a stake in this process and the eventual outcome may not necessarily reflect conservation goals.

Summary

R. raviventris is present in the Emeryville Crescent Marsh. Further research is necessary to gain details on its distribution and population ecology at this locality.

A number of proposed developments for the marsh could be detrimental for the survival of the species there. A suggested project to protect the SMHM in this area would start with the exclusion of human traffic by constructing fences along the highway and at either end of the marsh. Mimimal limits of this fence would be at Temescal Creek and the beginning of the Neck section. Interpretive information

and observation platforms made available at each end of the Crescent are recommended to increase public support and awareness of this natural resource. A full-time 'ranger' to monitor activities is suggested. The need to limit public access is important because of the sensitive character and small size of this marsh.

The loss of the Crescent as a habitat for R. raviventris would continue the trend toward range fragmentation of the species and bring it a step closer to extinction. It is hoped that the decisions concerning the Crescent's future will be favorable for the preservation of this endangered species.

REFERENCES CITED

Bailey, Stephen, Museum of Vertebrate Zoology, University of California, Berkeley. Personal communication, 1982.

Bodega Bay Institute, 1978. The Crescent, an environmental assessment of the Emeryville Crescent, Alameda Co., CA, submitted to the Golden Gate Audubon Society, 97 pp.

California Department of Fish and Game, August 1978. Salt marsh harvest moust trapping - Hoffman Marsh, conducted by James L. Michaels, 4 pp.

East Bay Regional Park District, 1980. Master Plan - 1980, 48 pp.

Fisler, George F., 1961. Behavior of salt marsh Microtus during winter high tides. Journal Mamm., Vol. 42, no. 1, pp. 37-43.

__________, 1965. Adaptation and speciation in harvest mice of the marshes of San Francisco Bay. Univ. Calif. Publ. Zool., Vol. 77, 108pp.

Fradkin, Philip L., 1979. The mouse that snored. Audubon, Vol. 81, no. 3, pp. 86-93.

IUCN, 1979. Red data book, Vol. I, Mammalia. Morges, Switzerland.

Johnston, R.F., 1957. Adaptation of salt marsh mammals to high tides. Journ. Mamm., Vol. 38, no. 4, pp. 529-531.

Koos, Peter, Principal Planner, East Bay Regional Parks District. Personal communication, 1982.

Schaub, David B., 1971. Salt marsh harvest mouse survey, 1971. California Dept. of Fish and Game, P-R Completion Report W-54-R-3, p. p. 35.

Shellhammer, Dr. Howard S., Dept. of Biology, San Jose State, California. Personal communication, 1982.

U.S. Army Corps of Engineers, 1980. Aerial photograph of the Emeryville Crescent, SFB-38-14, 6/17/80.

U.S. Dept. of Transportation, 1981. Freeway development of Route I-180 (17) in Contra Costa and Alameda Counties, FHWA-CA-EIS-78-01-F, 203 pp.

URS Research Company, 1973. Marine environmental impact analysis, widening of Highways 17 and 80 along shoreline of Richmond, California. Prepared for State of California, Division of Highways, 150 pp.

Wodolleck, J.T., W. Zolan, and G.L. Stevens, 1976. A population study of the harvest mice (R. raviventris) in the Palo Alto Baylands salt marsh. The Wasmann Journal of Biology, Vol. 34, no. 1, pp. 52-63.

Zetterquist, D.K., 1977. The salt marsh harvest mouse (R. raviventris) in marginal habitats. The Wasmann Journal of Biology, Vol. 35, no. 1, pp. 68-76.

Chapter 2

CHARACTERISTICS OF TRAMPLED MARSH SOIL AND POTENTIAL FOR REHABILITATION

James K. Doyle

Introduction

There are several ways one can look at the Emeryville Crescent sculpture area. Some see it as a playground and bring their dogs and kids to romp around. Some see it as an area of unique art forms and come to contribute to or just appreciate the sculptures. These people are generally pleased. Others see the area as a valuable salt marsh habitat and are not pleased. This latter view is the one adopted by this paper.

As a marsh, the sculpture area is in serious trouble. Large areas of soil and vegetation have been trampled by foot traffic on the marsh, producing completely bare areas and trails that do not recover. The soil is compacted or allowed to erode away. Often the trampled areas are depressed enough to produce inadequate drainage, forming permanent ponds. In many areas where pickleweed does grow, its biomass is significantly below normal. Trampling has removed approximately 10% of the area of the sculpture marsh from production.

Recently, a public workshop sponsored by the California Coastal Conservancy designated restoration and enhancement of the Emeryville Crescent as a high priority project (CHNMB Associates, 1982). If the sculptures are removed and access to the marsh is regulated, such a project may include restoration of the trampled marsh soil. Several chemical and physical soil tests have been performed for this study and comparisons made between trampled and non-trampled areas, to determine the need and potential for restoration.

Significance of Habitat Loss Due to Trampling

There are several continuing detrimental effects on the wildlife at the Crescent due to the way the area is used by humans (see paper by Lisa Cohen). However, only effects that would remain after human access is restricted are considered here. Trampled marsh areas represent a complete loss of habitat, except for a few invertebrates found mainly in the ponded areas (Bailey, 1982, pers. comm.). Sixty species of waterbirds are found at the Crescent, including several endangered

species: the California Brown Pelican, the California Least Tern, the Alameda Salt Marsh Song Sparrow, and the California Clapper Rail (Bodega Bay Institute, 1978). Recently, presence of the endangered Salt Marsh Harvest Mouse has been documented (see paper by David Olson). Many of these species have populations so low as to be subject to disruption of the gene pool by mutation. Every square meter of marsh habitat lost by trampling directly contributes to the decline of these species. Furthermore, the loss of marsh habitat lowers the influx of organic matter to the mudflats. This subsequently decreases the population of invertebrates that supports the birds. Finally, the Crescent is a unique wildlife area. It is the best and often only habitat for many bird species in the northern East Bay (Bailey, 1982, pers. comm.). The only place where the loss due to trampling can be fully replaced is at the Crescent itself.

Introduction to Methods

There are two limitations to this study that affect the choice of methods and the quality of the data. Both are constraints in time. First, the total amount of time available for research placed a limit on the number of samples and the variety of tests that could be done. When several methods were available for a given test, the simplest and least time-consuming was usually chosen. Some of the methods are "semi-quantitative," that is, they quantitatively determine a property of the soil but not the property that is desired. The desired property is related to the measured property in a consistent manner and must be calculated. Some tests that would have given useful information could not be done, including organic matter content and grain size distribution of the soil. No field tests of proposed rehabilitation procedures were possible.

The second constraint involves the time of year when samples could be collected, which was restricted to February and March. As will be shown, this limitation makes it difficult to determine exactly why the trampled areas remain bare but does allow the development of procedures to restore them. The tests were designed to give information on four factors suspected to prevent the growth of pickleweed in the trampled areas: salinity, alkalinity, soil compaction, and crust formation. Potential factors not addressed in this paper include the effects of tidal immersion, pond formation, soil erosion, and continued trampling.

Site Location and Selection

The Emeryville Crescent is an "L"-shaped tidal marsh and mudflat bounded on the south by the approach to the Oakland Bay Bridge, on the east by Interstate 80, and

on the north by the Emeryville Marina landfill (for detailed site description see papers by Lisa Cohen and David Olson). FIGURE 1 shows the present area of the sculpture marsh and the sample localities. Sixteen sample sites were selected in pairs of trampled and nontrampled soil at approximately the same distance from the shoreline. Three of the sites (1A, 5A, 7A) were located by taking readings on distant landmarks with a Brunton compass. The other sites were located in relation to these three sites by compass readings and pacing of distances.

Due to the disrupted state of the area, use of a random sampling design was not feasible. Sites were selected according to the following criteria: Trampled areas had to be completely bare of vegetation and free of driftwood and other debris. The pickleweed and other vegetation in the nontrampled areas had to be healthy. The two sites of a trampled/nontrampled pair had to occur within about 30 feet of each other. Finally, ponded areas were generally avoided due to the difficulty in extracting samples and because the absence of vegetation could be explained solely on the basis of ponding. The two exceptions were site 6A, which was ponded, and site 8B, which was a composite of two healthy areas, one closer and one farther from the waterline than site 8A.

Methodology for Soil Tests

Saturation Percentage (SP): Soil samples for the salinity and alkalinity tests were taken on February 21 and 22, 1982. Samples were dug with a hand trowel and stored in plastic bags. Sample depth was chosen as the top 15 cm. of soil, since pickleweed roots are confined almost exclusively to this zone (Mahall and Park, 1976b). Soil samples were passed through a sieve with 3 mm openings to remove roots, pieces of wood and plastic and other debris. Distilled water was added to the soil until saturation was reached. Samples were allowed to stand for one hour, and then the criteria for saturation were rechecked and adjustments made (Doner, 1982). Samples were then oven-dried at 105°C to constant weight. The saturation percentage was calculated from the following formula (USSLS, 1954):

$$SP = \frac{(\text{loss in weight on drying})(100)}{(\text{weight of oven-dry soil})}$$

pH of Saturated Soil Paste: The pH of the soil paste was measured with a glass electrode, CHEMTRIX type 40 pH meter. The electrode was raised and lowered repeatedly and allowed to equilibrate until a representative reading was obtained (USSLS, 1954).

Electrical Conductivity (EC) of the Saturation Extract: The saturation extract was obtained from the saturated soil paste by suction filtration through Wattman #42

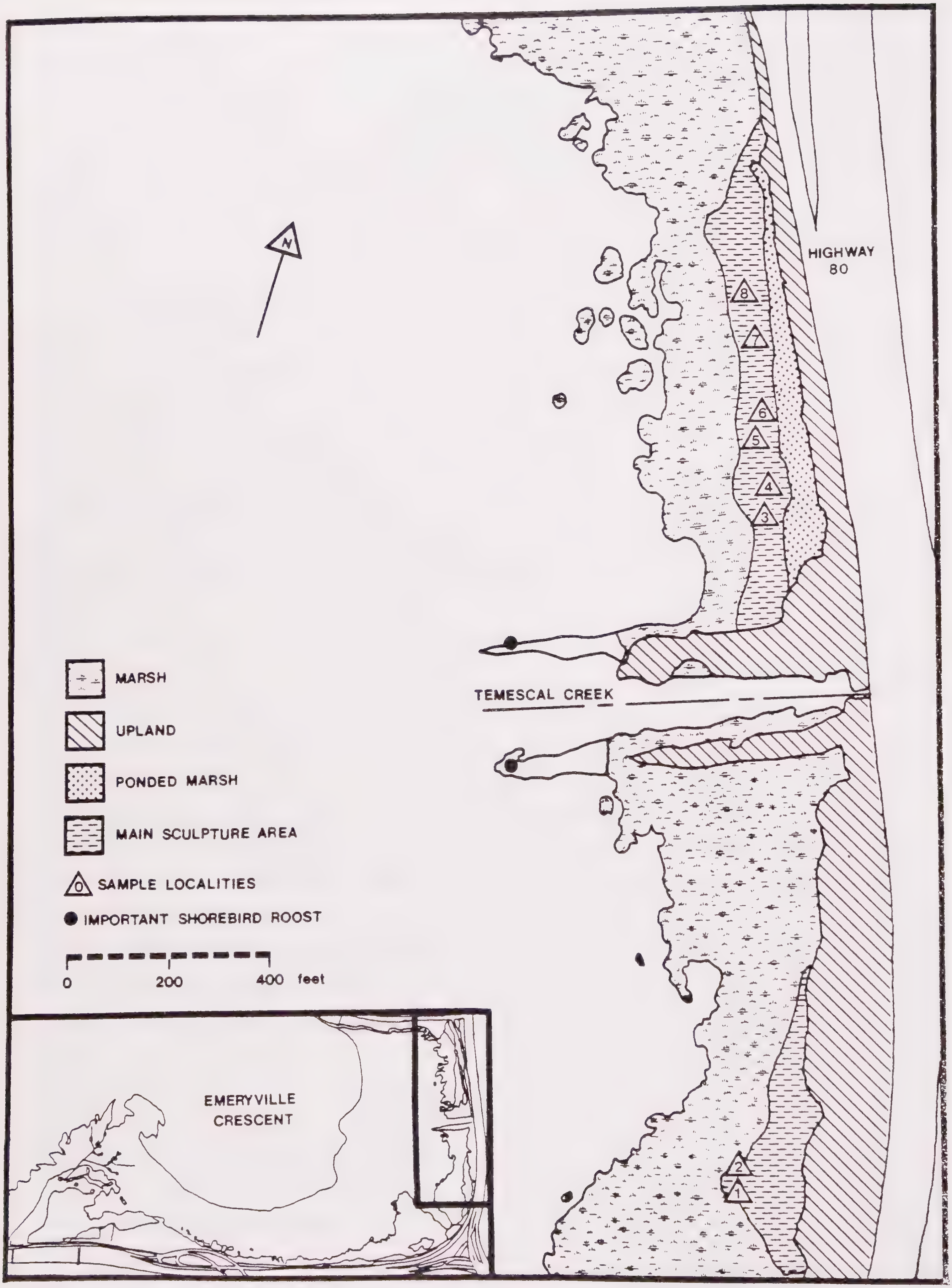

FIGURE 1. Sample Localities at the Emeryville Crescent Sculpture Marsh.

Sources: Bodega Bay Institute, 1978. Aerial photograph #SFB-38-14, U.S. Army Corps of Engineers, San Francisco, June 17, 1980.

filter paper in a Buchner funnel. Filtration was terminated when a sufficient amount of extract (5 to 10 ml) was obtained. The electrical conductivity was measured with a Beckman Model 16B2 Conductivity Bridge, using 0.01 N KCl as a standard reference solution. Readings were taken as resistance (R) and converted to EC at 25°C by the following formula (Doner, 1982):

$$EC(\text{mmho/cm}) = \frac{1.4118 \times R \text{ (of standard KCL)}}{R \text{ (of extract)}}$$

EC values were converted to percent salt in soil by making two assumptions. First, the total soluble cation concentration, in equivalents/liter of saturation extract, was approximated by EQ/L = 0.01 x EC (Doner, 1982). The second assumption concerns the exact composition of the solution salts. It has been shown that the salt breakdown in Suisun marsh soil is similar to that of sea water (TABLE 1) (Mall, 1969). Although differences may be expected due to their different locations, the salt composition of Suisun marsh soil was taken as the best available approximation for the soil at the Crescent. This composition corresponds to 57.16 gm/EQ. The amount salt in the soil was then calculated from the following equation:

$$\frac{\text{gm salt}}{\text{100gm soil}} = EC(\text{mmho/cm}) \text{ X } \frac{0.01 \text{ EQ/L}}{\text{mmho/cm}} \text{ X } \frac{57.16\text{gm}}{\text{EQ}} \text{ X SP in } \frac{\text{gm water}}{\text{100 gm soil}} \text{ X } \frac{0.001 \text{ L}}{\text{gm water}}$$

EC values were converted to milliequivalents per liter (MEQ/L) at field moisture by assuming field moisture to be near its maximum value. Since this maximum occurs at about half the saturation level, the following formula was used (USSLS, 1954):

$$\text{MEQ/L (FM)} = 2 \text{ X } EC(\text{mmho/cm}) \text{ X } \frac{10 \text{ MEQ/L}}{\text{mmho/cm}}$$

IONS	SUISUN MARSH SOIL EXTRACTS	SEA WATER
Cl^-	18.87 gm/L	18.98 gm/L
Ca^{+2}	0.96	0.40
Mg^{+2}	1.87	1.27
Na^+	10.71	10.56
K^+	0.33	0.38

TABLE 1. Composition of Salt in Suisun Marsh Soil and Sea Water.
Source: Mall, 1969.

Total Exchangeable Cations (TEC): Exchangeable cations were determined by an equilibrium pH method in which the cations are replaced by an excess of H^+. To 2.0 gm of air-dry soil was added 25 ml of 1 N HOAc (acetic acid). The suspension was shaken intermittently for one hour, then the pH was determined with a CHEMTRIX type 40 pH meter. TEC values in milliequivalents/100 gm soil were then read from a standard graph relating the pH of the HOAc solution to total exchangeable metallic cations in the soil (Jackson, 1958).

TEC values were converted to exchangeable sodium percentage (ESP) and exchangeable sodium (ES) values by making several assumptions. First, the composition of the soluble salts was again taken to be that of Suisun marsh soil. This corresponds to 69.84% Na^+, 7.13% Ca^{+2}, and 22.88% Mg^{+2} in terms of percent of total MEQ/L. Next the equation MEQ/L (soluble salts) = 10 X EC(mmho/cm) was assumed. The soluble sodium, calcium, and magnesium concentrations for the saturation extract of each sample were then calculated by the following equation:

$$\text{Specific cation concentration (MEQ/L)} = \text{EC(mmho/cm)} \times \frac{10 \text{ MEQ/L}}{\text{mmho/cm}} \times \% \text{ specific cation}$$

The ESP was estimated from the specific soluble cation concentrations by the following standard equations (USSLS, 1954):

$$\text{ESP} = \frac{100(-0.0126 + 0.01475x)}{1 + (-0.0126 + 0.01475x)}, \text{ where } x = \frac{Na^+}{(Ca^{+2} + Mg^{+2})/2}, \text{ all concentrations}$$

in MEQ/L. Finally, TEC values were taken to be equivalent to cation exchange capacity (i.e., all the exchange sites in the soil are occupied). This is a reasonable assumption for saline-alkali soils (Doner, 1982, pers. comm.). ES values were then calculated from the following formula:

$$\text{ES(MEQ/L)} = \frac{\text{EXP x TEC(MEQ/L)}}{100}$$

Bulk Density: Samples for the bulk density test were taken on March 6, 1982. Soil cores having field structure were obtained by thrusting plastic tubes of 0.95 cm diameter into the soil by hand. Core depth varied from 4-6 cm. Volume was determined by direct measurement of the length of the soil core. The samples were then dried to constant weight at 105°C.

Soil Crust Density: Samples for the soil crust density test were taken on April 18, 1982. Since crust pieces were generally not available directly on the

SOIL PROPERTY		SATURATION PERCENTAGE	pH OF SATURATED SOIL PASTE	ELECTRICAL CONDUCTIVITY	AMOUNT SALT IN SOIL	SALINITY AT FIELD MOISTURE	TOTAL EXCHANGEABLE CATIONS	EXCHANGEABLE SODIUM	EXCHANGEABLE SODIUM PERCENTAGE	BULK DENSITY	SOIL CRUST DENSITY
SOIL FACTOR		Salinity	Alkalinity	Salinity	Salinity	Salinity	Alkalinity	Alkalinity	Alkalinity	Soil Compaction	Crust Formation
UNITS		per cent	pH	mmho/cm	$\frac{\text{gm salt}}{\text{100gm soil}}$	MEQ/L	$\frac{\text{MEQ}}{\text{100gm soil}}$	$\frac{\text{MEQ}}{\text{100gm soil}}$	per cent	gm/cm^3	gm/cm^3
1	A*	68.5	7.30	53.0	2.08	1060	7.5	2.8	37.5	1.14	1.14
	B	162.5	6.40	22.3	2.07	446	8.1	2.3	27.8	0.84	
2	A	36.1	7.72	36.5	0.75	730	4.5	1.5	33.2	0.83	
	B	58.9	7.06	8.6	0.29	172	4.8	0.91	19.0	0.60	
3	A	129.1	7.03	30.8	2.27	616	8.0	2.5	31.2	0.86	1.26
	B	204.3	6.93	18.0	2.10	360	7.5	1.9	25.6	0.47	
4	A	73.3	7.30	42.9	1.80	858	9.6	3.4	35.0	0.90	
	B	196.0	6.68	31.7	3.56	634	14.5	4.5	31.2	0.38	
5	A	138.1	7.65	49.2	3.88	984	9.8	3.6	36.6	0.71	1.49
	B	212.2	6.95	17.0	2.06	340	7.5	1.9	25.0	0.64	
6	A	106.4	7.95	31.5	1.92	630	10.9	3.4	31.5	0.64	
	B	279.3	7.05	19.2	3.07	384	6.1	1.6	26.3	0.47	
7	A	74.2	8.57	63.0	2.67	1260	18.8	7.4	39.6	0.79	1.32
	B	171.2	6.90	19.9	1.95	398	9.1	2.4	26.6	0.67	
8	A	49.1	8.42	70.8	1.99	1416	14.4	5.9	41.0	1.35	
	B	116.2	7.10	13.8	0.92	276	7.5	1.7	23.1	0.66	
RANGE	A	36.1-138.1	7.03-8.57	30.8-70.8	0.75-3.89	616-1416	4.5-18.8	1.5-7.4	31.2-41.0	0.64-1.35	1.14-1.49
	B	58.9-279.3	6.40-7.10	8.6-31.7	0.29-3.56	172-634	4.8-14.5	0.91-4.5	19.0-31.2	0.38-0.84	
MEAN	A	84.4	7.74	47.2	2.17	944	10.4	3.8	35.7	0.90	1.30
	B	175.1	6.88	18.8	2.00	376	9.3	2.2	25.6	0.60	

Table 2. Data From Six Soil Experiments
*Note: Sample pairs are numbered 1 to 8. A indicates the trampled area, B indicates the nontrampled area.

sample sites, four sample areas were chosen that encompassed sites 1 and 2, 3 and 4, 5 and 6, and 7 and 8. Crust pieces were picked by hand from these areas and stored in plastic bags. The moisture content of the samples was determined by drying representative crust pieces to constant weight at 105°C. Several crust pieces were weighed, corrected for moisture content, and dropped in a water-filled 1000 ml graduated cylinder to determine volume by water displacement. Absorption of water by the crust pieces was minimized by taking volume readings within a few seconds of immersion.

Presentation of Data

The results of the six soil tests and associated calculations are compiled in TABLE 2. In addition to the laboratory tests, several observations were made at the marsh. The vegetation of sites 1B to 4B consisted solely of pickleweed, while that of sites 5B to 8B mainly of pickleweed, with some salt grass and other marsh grasses. On March 6, visible salt crusts were observed at all trampled sites except 6A, which was submerged. On April 17, soil crusts were observed on or within 15 feet of all trampled sites. The size of the soil crusts ranged from 1 to 16 square inches. Pickleweed seedlings, ranging up to 2.5 inches tall, were observed at all trampled sites. Except for one area of approximately 10 ft^2 near sites 1 and 2, these seedlings were seen only within about a foot of the edge of the bare areas. The seedlings grew both between and directly through soil crust pieces.

Salinity Tolerance of Pickleweed

Pickleweed is a low-growing, leafless, succulent-stemmed halophyte of the genus *Salicornia* (Bodega Bay Institute, 1978). The specific species at the Crescent is usually called *Salicornia pacifica* Standl (Atwater, 1979), or *Salicornia virginica* L. (Mahall and Park, 1976a). However, it is likely that these two species and others (*S. herbacea*, *S. europa*, *S. stricta*) are not actually separate species but simply different races of the same species adapted to the environmental conditions at different locations (Kadlec and Wentz, 1975). Pickleweed grows only during the spring and summer months, but maintains a perennial above-ground system throughout the winter. The tidal range of pickleweed extends from mean high water to the highest high tides (Mahall and Park, 1976a). Species of *Salicornia* are among the most salt-tolerant plants in the world and are termed facultative halophytes, meaning that optimal growth is obtained in a saline soil (Barbour, 1970). The upper limit of salinity that pickleweed can survive is not precisely

determined, since the various studies often widely disagree (TABLE 3). No published data for the tolerance of pickleweed to soil alkalinity were found.

TYPE OF PLANT MATERIAL	SPECIES[1]	UPPER LIMIT OF SALINITY TOLERANCE[2]	MEQ/L[3]	SOURCE
Mature	S. herbacea	4.5% salt	787	Barbour, 1970
Mature	S. europa	9.0% salt	1575	Barbour, 1970
Mature	S. virginica	81 gm/liter salt	1417	Mall, 1969
Mature	S. stricta	4.25% salt	744	Chapman, 1960
Seedlings	S. herbacea	very poor growth at 5.0% NaCl	855	Barbour, 1970
Seedlings	S. virginica	zero growth at 2.2% salt	385	Barbour and Davis, 1970
Seeds	S. europa	8% germination at 5.0% NaCl	855	Ungar, 1962
Seeds	S. stricta	12% germination at 10% salt	1749	Chapman, 1960
Seeds	S. herbacea	0.4 M NaCl	400	Waisel, 1972

TABLE 3. Salinity Tolerance of Pickleweed.

[1]Data for several species are included because of the uncertainty concerning the speciation of Salicornia.

[2]Some values are field tests and some are hydroponic laboratory tests, but all refer to the salinity of the water or soil-water actually experienced by the roots or seeds.

[3]Conversion of values to MEQ/L was made using 57.16 gm/MEQ for "salt" and 58.5 gm/MEQ for NaCl.

Discussion of Data

Salinity: The EC of the saturation extract is generally regarded as the best measurement of soil salinity in relation to plant response. The salt concentration of the soil solution experienced by the plant depends not only on the amount of salt present but on the amount of water present. Therefore, two soil samples (such as 1A and 1B) can have the same amount of salt present and still exhibit a large difference in salinity (EC) due to the difference in their ability to hold water as measured by the saturation percentage (USSLS, 1954). The EC values for the trampled areas are consistently higher than those for the corresponding nontrampled areas, with little overlap in the range of values.

The breakdown into gm salt/100gm soil and SP explains why these differences exist. Partly it is because there is commonly more salt in the trampled areas, sometimes over twice as much as in the corresponding nontrampled area (sites 2 and 8).

However, this trend is not completely consistent, being sharply reversed for sites 4 and 6. The more consistent and more significant trend is the saturation percentage. SP values for the nontrampled areas are consistently higher than the corresponding trampled areas and are often very high in magnitude. While the correlation with soil grain size distribution remains to be tested, the most likely explanation for the SP differences is a much higher organic matter content for the nontrampled areas (Doner, 1982, pers. comm.). Organic matter in high concentration can make soil act like a sponge, soaking up more than twice its weight in water (USSLS, 1954).

It is not certain whether the salinity in the trampled areas exceeds the tolerance of pickleweed. The concentration of soluble salts at field moisture for trampled areas averaged 944 MEQ/L. This value exceeds some, but not all, of the salinity limits in TABLE 3. But there is one more thing to consider. Marsh soil salinities are at their lowest point during the winter, due to the flushing of salts from the soil by rainfall. Salinity can be expected to increase significantly throughout the summer because of increased evaporation of the tidal water on the marsh (Chapman, 1960). For example, the Suisun marsh increases in average salinity by 87% in the pickleweed zone between April and September (Mall, 1969). Furthermore, it is probable that salinity would increase more during the summer for the trampled areas than for the healthy areas because the presence of vegetation reduces the evaporation rate of tidal water, and the healthy areas have much better drainage and permeability to water than the bare areas (Chapman, 1960). If salinity at the Crescent is assumed to increase by 87% over the summer (an uncertain comparison, since the Suisun marsh is more brackish than the Crescent), the average summer value for the trampled areas, 1765 MEQ/L, would exceed all of the salinity limits. While data for late summer are needed for confirmation, excessive salinity appears to be a major deterrent to the growth of pickleweed in the trampled areas.

Alkalinity: Soil particles adsorb cations due to electrical charges on the surfaces of the particles. These cations are chemically bound to the soil and are therefore not soluble. They can be replaced by other cations in the soil solution, however, hence the term exchangeable. Alkalinity refers to the percent of the total exchange sites occupied by sodium ions. The main effect of high alkalinity is on the structure of the soil. As alkalinity increases, the soil becomes more dispersed, resulting in low permeability and the formation of soil crusts upon drying. High alkalinity can also disturb the nutritional balance of plants by removing calcium from plant tissues (USSLS, 1954).

The soil pH shows a consistent trend toward higher values in trampled areas. The usual interpretation of pH is in terms of H^+ concentration, but the exact

property measured by soil pH is unknown. The pH data are useful mainly as a check on the ESP values, since higher soil pH values are commonly correlated with higher ESP values (USSLS, 1954). Thus the pH test increases confidence in the ESP calculations.

The ES and ESP values show a consistent trend, those in the trampled areas being higher than in the healthy areas by varying amounts. The differences in ESP (especially at sites 7 and 8) would be significant for a non-halophyte, but the effect of such high alkalinity on pickleweed is not known. Higher alkalinity in the trampled areas would most likely produce an additional stress on pickleweed plants, but assigning a magnitude to this stress awaits further research.

Soil Compaction: The effect of soil compaction, as measured by bulk density, includes prevention of root penetration and seedling emergence and decreased ability of the soil to conduct water. Drainage difficulties can be expected at bulk densities of about 1.7 gm/cm^3. Difficulties in root penetration and seedling emergence begin at bulk densities of about 1.8 gm/cm^3 (USSLS, 1954). None of the bulk densities tested reach these limits, the highest (8A) being 1.35 gm/cm^3. However, the trend toward higher bulk densities in the trampled areas is consistent, and one trampled area (4A) has a bulk density over twice as high as its corresponding healthy area. As shown by the SP test, the nontrampled areas generally have much more organic matter than the trampled areas. Since organic matter is much lighter than soil particles, most of the bulk density difference is probably due to the difference in organic matter content, rather than soil compaction. Soil compaction is probably not restrictive to the recolonization of pickleweed in the trampled areas. Any lesser detrimental effect cannot be determined from these data.

Crust Formation: Hard surface crusts can develop due to high exchangeable sodium, low organic matter, and the wetting of soil to zero tension. All of these occur in the bare areas at the Crescent. The main effect of soil crusts on plants is as a barrier to seedling emergence (USSLS, 1954). Even the highest soil crust density measured for a trampled area (1.49 gm/cm^3 at sites 5 and 6), lies well below the 1.7 gm/cm^3 limit expected to cause major problems for seedlings. This is supported by the observation of seedlings growing directly through the crust pieces. It is likely that the problem will worsen as the summer progresses, but as of April, crust formation was not sufficient to prevent recolonization of the trampled soil.

Marsh Rehabilitation: A Definition

The creation of marsh habitat is usually described as "marsh restoration." The situation at the sculpture marsh is quite different, and the term "marsh

rehabilitation" is preferable. Marsh restoration refers to creating marsh where it does not presently exist, whereas the areas needing rehabilitation at the Crescent are surrounded by healthy marsh. Therefore, marsh restoration techniques may not necessarily be applicable. For instance, the entire sculpture marsh cannot be diked off while restoration work is being done, because this would kill the 90% of the marsh that is healthy. Furthermore, marsh rehabilitation has some unique problems, such as the possible interference of work by the tides and the fact that most of the work must be done by hand, not machine. In view of the variation in the values for the soil tests in TABLE 2, marsh rehabilitation could be a very detailed procedure. The amounts of any amendments added to the soil would vary widely from site to site. Although the sculpture marsh is a unique situation in some ways, the following rehabilitation methods could be used in other marshes trampled by human or animal traffic. These procedures may also be useful when a marsh restoration procedure partially fails, and undesired salt pans are produced.

The Need for Rehabilitation

The desirability of a rehabilitation effort at the Crescent depends on how long it would take for the marsh to recover naturally. For the ponded areas, natural recovery in any foreseeable time period is unlikely. Sedimentation may eventually fill the ponded areas, but it might aggravate the problem instead, since most of the sediments would be trapped by the surrounding vegetation (Pestrong, 1972). Since natural drainage channels haven't formed over the last 15 years, there is little reason to expect them to do so in the future. Recolonization by pickleweed seedlings at the rate observed in the spring of 1982 would take decades to complete. Some recolonization will probably occur in a few years if access to the area is restricted, but total recovery to pre-trampled productivity levels for the entire sculpture marsh would most likely take 50 years or more (Bailey, 1982, pers. comm.).

Methods for Marsh Rehabilitation

The February data in this paper is ideal as a basis for developing rehabilitation methods, because a rehabilitation effort should certainly begin at the end of winter when soil salinity is at a minimum. The basic goal is to change the values for the trampled areas given in TABLE 2 to match those for the corresponding nontrampled areas. The following methods should be considered only as informed suggestions, since the actual procedures must be determined by field trials.

Soil salinity can be reduced either by removing salt or by increasing the ability of the soil to hold water (SP). The only practical way to remove salt

from the trampled areas would be surface flushing with large quantities of water. This would involve pumping sea water to the trampled areas to provide a continual flow. Sea water would be effective in removing salt, even though it is quite salty itself. The salinity of the soil solution in the trampled areas averaged 944 MEQ/L, while that of sea water is only 218 MEQ/L (Mall, 1969). Since the salinity of sea water lies within the salinity range found in the healthy marsh areas, there should be no serious detrimental effect on the healthy areas due to the flushing process. The high water table in the marsh should prevent any undesired downward movement of salt during flushing.

The effectiveness of flushing can be determined only by doing it, but it is likely that flushing would need to be supplemented by a second method: the addition of organic matter to increased the saturation percentage. The EC values that the trampled areas would have if the SP equalled that of the corresponding nontrampled area are given in TABLE 4, column 1. All but one of these values (5A) fall below the highest EC value of a nontrampled area. The SP value required to reduce the EC of the trampled areas to that of the corresponding nontrampled area is given in column 2. All of these values except that for site 5A are attainable (USSLS, 1954). The ideal type of organic matter to use would be green organic matter, such as grass clippings, because of its high nitrogen content. The next choice would be peat moss. Dry organic matter, such as straw, could be used as long as attention is paid to its effect of lowering the nitrogen content of the soil, and nitrogen is added if necessary (Doner, 1982, pers. comm.). Any sites not correctable by flushing and organic matter addition could probably be

SAMPLE NUMBER	EC IF SP: THAT OF HEALTHY AREA 1	SP REQUIRED TO REDUCE EC TO HEALTHY AREA EC 2
1A	22.4	163.2
2A	22.3	152.9
3A	19.4	220.0
4A	16.1	99.3
5A	32.0	400.3
6A	12.0	174.9
7A	27.3	234.7
8A	30.0	252.3

TABLE 4. Effectiveness of Decreasing Salinity by Increasing the Saturation Percentage.

saved by the addition of fill. Fill will be required anyway because of the poor drainage of many of the trampled areas, and soil could be traded between problem areas and easily-corrected areas if necessary. The fill should be silty clay in order to have a good water-holding ability.

The usual method for reducing alkalinity in soils is by replacement of the exchangeable sodium with calcium. This is done by adding a chemical amendment such as gypsum, sulfur, or limestone. However, it is not known whether this method is applicable in this case because the tides may wash away the chemicals and the high concentration of soluble sodium may interfere with the replacement of exchangeable sodium. Furthermore, since it has been shown that the addition of organic matter can counteract the unfavorable effects of exchangeable sodium (USSLS, 1954), it is possible that the alkalinity problem would be solved as a "side-effect" of the solution to the salinity problem. And, as previously discussed, it is not known whether the high ESP values of the trampled areas need correction at all. Clearly, more research is needed in this area.

The remaining soil problems are more easily corrected. The addition of organic matter should reduce the bulk density of the trampled soil considerably. Mechanically breaking up the soil, using a mechanical rototiller or just shovels, would be all the additional work needed to correct the bulk density values. Since soil crusts form because of high alkalinity and low organic matter content, no further treatment beside that described above should be needed to prevent crust formation. Finally, once the osil has been rehabilitated, recolonization of pickleweed should occur quickly even without transplants (Hinde, 1954). However, transplantation of _S. virginica_ has been shown to be easily accomplished, with 100% survival for plants transplanted within the same tidal zone (Batson and Stalter, 1969). With abundant sources of mature plants within a few feet of the trampled areas, this procedure would be both quick and effective. Seeds and seedlings found in the marsh could be collected, stored and then planted after the soil has been prepared for them.

Conclusion

The above arguments demonstrate both the need for and feasibility of marsh rehabilitation at the Emeryville Crescent sculpture marsh. However, whether such a project becomes a reality depends on political, economic, and social decisions yet to be made. It is hoped that these decisions will be made soon, because the sculptures are steadily spreading. At the southern end of the marsh is an incredibly authentic-looking driftwood replica of the Lunar Module. Unfortunately,

the surrounding landscape is just as authentic-looking, a perfect replica of the bare and lifeless moon. One small step for man........

REFERENCES CITED

Atwater, B.F., S.G. Conard, J.N. Dowden, C.W. Hedel, R.L. MacDonald, and Wayne Savage, 1979. History, Landforms, and Vegetation of the Estuary's Tidal Marshes, pp. 347-385, in San Francisco Bay, The Urbanized Estuary, T.J. Conomos, ed.: Pacific Division of the American Association for the Advancement of Science, San Francisco.

Bailey, Stephen, Senior Ornithologist, Golden Gate Audubon Society; Museum of Vertebrate Zoology, University of California, Berkeley. Personal communication, April 14, 1982.

Barbour, M.G., 1970. Is Any Angiosperm an Obligate Halophyte?: The American Midland Naturalist, v. 84, no. 1, pp. 105-117.

Barbour, M.G., and C.B. Davis, 1970. Salt Tolerance of Five California Salt Marsh Plants: The American Midland Naturalist, v. 84, no. 1, pp. 262-265.

Batson, W.T., and Richard Stalter, 1969. Transplantation of Salt Marsh Vegetation, Georgetown, South Carolina: Ecology, v. 50, no. 6, pp. 1087-1089.

Bodega Bay Institute, 1978. The Crescent: An Environmental Assessment of the Emeryville Crescent: Bodega Bay Institute, San Francisco, 99 pp.

Chapman, V.J., 1960. Salt Marshes and Salt Deserts of the World: London, Leonard Hill, Ltd., 392 pp.

CHNMB Associates, 1982. Draft East Bay Shoreline Report for the State Coastal Conservancy: CHNMB Associates, San Francisco, 23 pp.

Doner, H.E., Professor of Soil Chemistry, University of California, Berkeley. Personal communications, February to June, 1982.

__________, 1982. Chemical Analysis of Extracted Soil Solution, unpublished paper: Berkeley, 9 pp.

Hinde, H.P., 1954. The Vertical Distribution of Salt Marsh Phanerograms in Relation to Tide Levels: Ecological Monographs, v. 24, no. 2, pp. 209-225.

Jackson, M.L., 1958. Soil Chemical Analysis: Englewood Cliffs, Prentice-Hall, Inc., 498 pp.

Kadlec, J.A., and W.A. Wentz, 1975. State of the Art Survey and Evaluation of Marsh Plant Establishment Techniques: Induced and Natural, Volume 1: Report of Research: U.S. Army Engineering Waterways Experiment Station, Contract Report D-74-9, Vicksburg, 231 pp.

Mahall, B.E., and R.B. Park, 1976a. The Ecotone Between Spartina foliosa trin. and Salicornia virginica L. in Salt Marshes of Northern San Francisco Bay. II. Soil Water and Salinity: Journal of Ecology, v. 64, no. 3, pp. 793-809.

__________, 1976b. The Ecotone Between Spartina foliosa trin. and Salicornia virginica L. in Salt Marshes of Northern San Francisco Bay. II. Soil, Water and Salinity: Journal of Ecology, v. 64, no. 3, pp. 793-809.

Mall, R.E., 1969. Soil-Water-Salt Relationships of Waterfowl Food Plants in the Suisun Marsh of California: Sacramento, The Resources Agency, U.S. Department of Fish and Game, 59 pp.

Pestrong, Raymond, 1972. San Francisco Bay Tidelands: California Geology, v. 25, no. 2, pp. 27-40.

Ungar, I.A., 1962. Influence of Salinity on Seed Germination in Succulent Halophytes: Ecology, v. 43, no. 4, pp. 763-764.

(continued)

United States Salinity Laboratory Staff (USSLS), 1954. Diagnosis and Improvement of Saline and Alkali Soils: U.S. Department of Agriculture, Agricultural Handbook No. 60, Washington, D.C., 160 pp.

Waisel, Yoav, 1972. Biology of Halophytes: New York, Academic Press, Inc., 395 pp.

Chapter 3

EMERYVILLE CRESCENT:
THE SCULPTURE GARDEN CONTROVERSY

Lisa Cohen

Introduction

Open space situated within a densely populated urban environment plays an important role. It offers a change in scenery from the crowded city streets, provides a habitat for wildlife, and can be used for recreational purposes. The conflict between conservation and recreation is longstanding and very complicated. It entails questions about land use, both in rural undeveloped areas and within cities. Should the land be set aside and made inaccessible to the public in an attempt to conserve and preserve what is there, or should the rich resources of the natural environment be made available for the enjoyment of the public by creating recreational sites and facilities? Furthermore, by conserving an area of open space, is the possibility of recreation necessarily eliminated? And if an area is opened up for recreation does that imply that the natural resources and beauty cannot be conserved?

The Emeryville Crescent embodies such a conflict because it is, on the one hand, the primary habitat for many species of birds and a valuable and productive salt marsh. On the other hand, it is a popular site for many recreational activities including birdwatching, walking, dog running, and sculpture building. Because of the resources at the Crescent and its location within a heavily urbanized environment, it has much environmental and social significance. However, it is not clear whether the use of the area for recreational purposes is compatible with efforts to conserve the salt marsh and wildlife that exist at present.

The fundamental issue concerning the Crescent is whether the area should be open to public access and used as a recreational facility, or whether a wildlife preserve should be created and public access restricted. Strong supporters of preservation argue that recreational usage of the area is disruptive to the natural ecosystem and wildlife, while proponents of recreation stress the uniqueness and social significance of the Crescent, and the compatibility of recreation with the

needs of the wildlife. It is my belief that preservation can coexist with recreational usage of the area. However, compromises will have to be made. Some marshland destruction and birdlife disturbance will result from the presence of dogs and people at the Crescent, but if certain restrictions are placed on the types of recreational activities allowed at the Crescent, damage can be minimized. I will examine the conflict between conservation and recreation at the Crescent by outlining the resources at the Crescent, their use, the problems associated with their use, and the recommendations for future use of the area.

Site Description

The Emeryville Crescent occupies the area west of the Eastshore freeway between Powell Street and the approach to the Bay Bridge toll plaza (FIGURE 1). Two hundred years ago, open water and tidal flats occupied this entire area. Since the nineteen twenties, however, filling, diking and dredging have altered the Crescent significantly. The southern arm of the Crescent between the Oakland storm drain and the

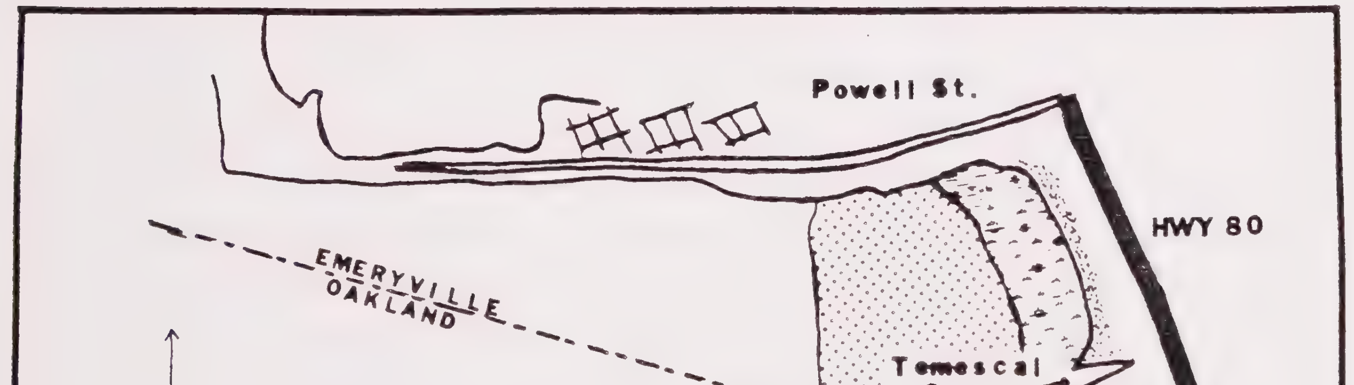

FIGURE 1. Emeryville Crescent.
Base Map: USGS.

Oakland Rod and Gun Club was filled between 1929 and 1940. The northern arm between Temescal Creek and Powell Street was created by fill between 1953 and 1967 (see Allison Turner's report). Now a continuous salt marsh stretches from the toll plaza to Powell Street.

The Crescent is owned by Santa Fe Land, Inc., but the shoreline, marsh and water are regulated by Bay Conservation and Development Commission (BCDA) and the Army Corps of Engineers. At one time, Santa Fe proposed to fill the marsh and build condominums for housing (Wakeman, pers. comm., 1982). Presently, it is unclear what Santa Fe plans for the area. The City of Emeryville has zoned the Crescent as residential.

Driftwood and other debris is carried in from the bay by tidal action and deposited on the northernmost portion of the marsh (adjacent to Powell Street), where it collects in large quantities. The wood is used to build driftwood sculptures in the marsh. A large sculpture garden extends from south of Temescal Creek north to Powell Street (FIGURE 1). In addition to sculpture building, the Crescent is used by people to observe the birdlife in the salt marsh, to walk dogs and hike, and to picnic. The southern end of the Crescent by the toll plaza is occupied by the Oakland Rod and Gun Club, otherwise known as the Duck Club.

The Biology

The biology of the Crescent is very diverse. The salt marsh biome predominates, and the major plant species include pickleweed (*Salicornia*), cordgrass (*Spartina foliosa*), and salt grass (*Distichlis spicata*). The salt marsh is the primary producer for the marine ecosystem; the energy-generating capacity of cordgrass is two to seven times greater than that of an equal acreage of wheat. Most of the marsh productivity goes into the bay waters as detritus, which provides food for animals higher in the food chain. Marshes are an important source of oxygen which is needed by the water in order to support marine life, and the salt marsh acts as a sink for aerial and water-borne pollutants (Bodega Bay Institute, 1978).

The second major biome, the mudflats, lies below the low tide mark and extends into the bay. The mudflats support numerous animal species, including worms, crabs and mussels. These animals are integral links in the food chain. Upon decomposition they enter the detritus pool, and, together with the decomposed salt marsh plants, serve as a major food source for mussels, shrimp and crab which, in turn, feed fish.

The Crescent supports the largest number of bird species found along the shoreline of San Francisco Bay, including a significant portion of the San Francisco Bay wintering shorebird population (Harvey, et al., 1977). Over ten thousand birds have been estimated to winter at the Crescent, representing up to fifty different species. Herons, egrets, ducks, geese, shorebirds, gulls and terns are among the most common birds found at the Crescent. In addition, a few endangered species inhabitat the area, including the California Clapper Rail, and the Brown Pelican. The Crescent is an important nesting, roosting, wintering and feeding site for the birdlife found there. For the Clapper Rail, it is the only wintering ground in all of California. For other birds, it is the only wintering site in all of North America.

The Salt Marsh Harvest Mouse also inhabits portions of the Emeryville Crescent. It is endemic to the salt marshes of the San Francisco Bay region. It is listed as an endangered species due to the rapid destruction of its limited habitat. Recreational use of the Emeryville Crescent may further limit mouse habitat. (See the report by David Olson for an in-depth discussion of mouse populations at the Crescent).

The Sculptures

The Emeryville Mudflat sculpture garden dates back at least twenty years. Perhaps the first people to utilize the driftwood that collected at the Crescent were members of the Oakland Rod and Gun Club. They built duckblinds and occasionally an interesting sculpture (Sommer, 1979).

By 1961, the Emeryville sculpture garden was underway, initiated by a group of students from the California College of Arts and Crafts who were studying the work of a German artist, Kurt Schwitters. His aptly named Merz Art, taken from the German word Kommerz, was created from the odds and ends of commerce. The students, inspired by Schwitters' collages, went down to the Emeryville mudflats and created a sculpture from the driftwood they found (Sommer, 1975). From then on, people have been building sculptures at the Crescent.

The historical significance of the sculpture garden is great. It was one of the vehicles used for expressing the political and social ideas that were raised during the 1960's and early 1970's. A few pieces from this early period still stand. For example, the large platform just north of Temescal Creek which was used as a stage for plays, concerts and rallies for many years, is now used by picnickers and sunbathers.

The sculpture garden enjoys local fame. It is highly visible from the Eastshore freeway and attracts the attention of the motorists driving along the freeway and Frontage Road. Several articles have been written about the area in local magazines and newspapers (Feelie, 1973), and a book has been written specifically about the sculpture garden (Sommer, 1979).

Non-Environmental Problems

There are specific problems associated with the presence of the sculpture garden. The uniqueness of the sculptures creates a distraction to motorists along Highway 17 and Frontage Road. If drivers slow down in order to look at them, the congestion along this stretch of road increases, and serious traffic accidents could result. There is no designated parking along the portion of Frontage Road adjacent to the Crescent. People park illegally, however, and the presence of these cars could also lead to increased congestion and possible accidents.

Some people feel the sculptures disrupt the view along the shoreline and destroy the beauty of the natural coastline. Others have criticized the increasing use of materials not found at the Crescent in the sculptures, such as paint and plastic. Not only has this phenomenon marked a change in the original "rules" of sculpture building--only materials found at the site could be used in the sculpture--it has led to an overall decline in the creativity and appearance of the sculptures. Finally, problems arise over ownership rights and public use. Although the Crescent is legally owned by Santa Fe Land, Inc., the public may have some rights to the land because of its long and continued use (Wakeman, pers. comm., 1982).

Environmental Problems

In addition to the non-environmental problems created by the use of the Crescent for recreation, there are environmental problems as well. In the following section, I will discuss the specific issues of environmental impact: salt marsh and soil degradation, the effects of the degradation on productivity and wildlife, and the disturbance of fauna.

Trampling by dog and foot traffic causes the greatest damage to the salt marsh. Pickleweed and cordgrass are extremely sensitive to such trampling. They show signs of trampling with just a little disturbance, and recover very slowly. The effect of trampling is not only visually displeasing, but biologically harmful as well.

The soil in the salt marsh is easily compacted. With the repeated impact by dog and foot traffic, permanent paths are created, and the soil becomes extremely

hard and unable to support plants. The ability of this soil to recover has been studied by Jim Doyle (see his paper).

The loss of the salt marsh has a negative impact on the larger marine ecosystem. The fishing and shellfish industry rely heavily on the production of the salt marsh. "Most of the commercial and sport fisheries of the Central Valley and of the bay are dependent on the quality and quantity of marshes, mudflats and open water and permanently submerged areas" (Harvey, _et al_., 1977, p. 49). The continued degradation of the salt marsh will mean less fish and shellfish available for human consumption, and may have a negative impact on the local economy.

Another major environmental impact that recreational use has on the Crescent is the disruption of the bird habitat. The roosting, nesting and feeding sites of the birds are very specific, and easily disturbed by the presence and movement of dogs and people. Dogs pose the greatest problems because they chase after birds and flush them from their roosting sites (Stephen Bailey, pers. comm., 1982). The primary habitat for the endangered California Clapper Rail is the pickleweed and cordgrass marsh. The Clapper Rail can no longer be found in the sculpture area north of Temescal Creek, and if the sculptures continue to spread south of the creek outlet, the bird could disappear altogether (Stephen Bailey, pers. comm., 1982).

The Emeryville Crescent is a habitat bridge. This means that it is a necessary location for the continuation of many of the bird species which inhabit the area. If the Crescent is destroyed, the evolution of the bird species may be seriously hampered (Bodega Bay Institute, 1978).

Recommendations for Future Use

Opinions are divided about the best future use of the Emeryville Crescent. The various interest groups, governmental and regulatory agencies, environmental groups and individuals involved in the planning for an East Bay Shoreline Park have issued statements and recommendations concerning the future of the Crescent. In the following section, I will summarize these recommendations, and then suggest what needs to be done before a final decision can be made about the future use of the Crescent.

Although there are a variety of opinions concerning the best use of the Crescent, the recommendations can be divided into two basic categories: the first emphasizes preservation of the Crescent by limiting and controlling access to people and dogs; the second stresses recreation at the Crescent by providing public access and recreational facilities.

The Case for Preservation

The Department of Parks and Recreation has described the Emeryville Crescent as "an important wildlife area which ultimately could be acquired and managed by the U.S. Fish and Game as part of the S.F. Bay Wildlife Refuge System. Public access to these wetlands should be controlled because of their fragile character" (DPR, 1982).

The Bodega Bay Institute report on the Crescent concludes that the Crescent would be best protected and managed as a wildlife preserve, with strictly controlled public access. The Institute feels that the driftwood sculpturing requires planning and regulation to avoid considerable habitat destruction. "Past attempts to exclude people from this area, including bulldozing of the sculptures and rigorous parking enforcement, have met with little success" (Bodega Bay Institute, 1978, p. 28).

The Audubon Society is very concerned with the continuing southward expansion of the sculpture garden. A special committee within the Society on the Emeryville Crescent has been very involved with efforts to preserve the Crescent. It has made direct appeals to the Coastal Conservancy, Public Trust for Lands, and the U.S. Fish and Wildlife Service, among other environmental and governmental agencies, to have the Crescent restricted to public access and made into a wildlife refuge and preserve. According to Stephen Bailey, the committee is most concerned with the expansion of the sculpture area south of Temescal Creek, and the subsequent destruction of the marsh and bird habitat by dogs and people. If the sculptures were restricted to the area north of Temescal Creek, the damage would be reduced by half. Neither the movement and noise emanating from the traffic on the Eastshore freeway, nor the birders and the Duck Club members in the south marsh seem to create any disturbance among the birdlife (Stephen Bailey, pers. comm., 1982).

The Case for Recreation

The East Bay Regional Park District (EBRPD) classifies the Crescent as Shoreline, and if it were under the control of the district, would operate the Crescent as a Regional Preserve. The purpose of a Regional Preserve, according to the District, is to protect features and outstanding elements of natural or historical significance, making them available for the enjoyment and education of the public (EBRPD, 1980). The District feels that the Crescent does need protection because of the valuable bird life and salt marsh (the next closest marsh is six to seven miles south of the Crescent in San Leandro), but it is also suitable for trail building and driftwood sculpturing. It is possible to design a trail around

the area without disrupting the salt marsh. This could be done by using physical barriers, such as moats and fences (Koos, pers. comm., 1982). The sculptures, if restricted to the areas closest to the highway and access points, could be continued without great impact on the marsh (Koos, pers. comm., 1982). Past experience has led the District to conclude that the creation of a park results in the education of the users about the environment and potential damage that could occur from misuse of the area. Consequently, the area is used less destructively than before a park is created (Koos, pers. comm., 1982).

The Bay Conservation and Development Commission (BCDC) general policy concerning marshes is that "carefully selected, designed and controlled areas should be made accessible to the public so that the unique educational, aesthetic and recreational values that marshes offer can be fully enjoyed" (Harvey et al., 1977). Like the EBRPD, the BCDC believes that if the impact is not too severe, it is better to provide limited access to an area rather than to eliminate access. The BCDC goal is to involve people with the bay. The idea of creating a wildlife refuge without public access is contrary to this goal (Wakeman, pers. comm., 1982).

Lynn Brenner, from the City of Berkeley Parks Design Section, feels that it is very difficult to keep people from using an area even if there are rules and regulations restricting public access. The best thing to do is to create a limited-access recreational area with raised boardwalks, interpretive signs, trailmarkers, and observation platforms (at the north and south ends of the marsh) for birdwatching.

The users of the Emeryville Crescent have expressed a strong interest in the continuing presence of the sculpture garden. Most of the people I spoke with in the sculpture garden said that the sculptures were interesting, unique, and important part of the history of the East Bay, and that they didn't interfere with the wildlife at the marsh. They would like to see the marsh left open to public access and sculpture building. (For a more detailed account of the users' opinions about the Crescent, see paper by Grant Edelstone).

In his book on public artwork, the UC Davis psychologist Robert Sommer has written: "It seems most logical to regard these salt marshes as multi-use areas in which the sculptors and their admirers as well as birds and birdwatchers can co-exist harmoniously as they have done in these past years" (Sommer, 1979, p. 16). He would like to see this area designated as an undeveloped regional park. "It is the most accessible public sculpture gallery where people can create their own

artwork. Nowhere is the marriage of art and biology as harmonious as on this small stretch of neglected shoreline" (Sommer, 1975, p. 41).

I would like to see the continuation of a sculpture garden at the Crescent, but restricted to the area north of Temescal Creek. This section of marsh is already severely damaged, and the endangered Clapper Rail can no longer be found here. Sculpture building south of the creek outlet should be prohibited, and a series of boardwalks and interpretive signs describing ghe marsh ecosystem and the wildlife should be constructed in this area. Dogs should not be allowed in the Crescent south of Temescal.

The continued use of the Emeryville Crescent for recreational activities will create some disturbance of the birdlife and the salt marsh, but the damage can be minimized if recreational use is controlled and properly managed. I feel that recreation and preservation are compatible at the Crescent, if compromises are made, and people use the area in the least disruptive manner.

Conclusion

The diversity of opinion presented above serves as an indication of the complexity of the issue, and the difficulty there is in making a decision about the future use of the Emeryville Crescent. The advocates of preservation feel that the natural environment and resources of the Crescent need protection, and the best way to protect is to restrict the public from using the area. The advocates of recreation feel that the natural environment and resources of the Crescent should be made available for the education and enjoyment of the public.

Several questions still need to be answered. What should be done with the existing sculptures if a wildlife preserve is created? How will restrictions be enforced and access regulated at the Crescent? Will the *status quo* behavior, established over a period of twenty years, change? How can public interests best be served? How will the wildlife and salt marsh best be protected?

In addition to answering these questions, studies must be carried out before a workable solution for the future of the Crescent can be arrived at. A quantitative analysis of disruption must be done in order to determine the amount of disturbance of the birdlife due to the presence of people and dogs in the marsh, the impact of dog and foot traffic on marsh productivity, and the effect of trampling on the marsh soil. Some of this work has already been started by Jim Doyle and David Olson (see their papers). In order to assess the success of raised boardwalks and platforms in marsh preservation, a survey of existing marshland

parks and preserves utilizing these structures should be carried out.

The general public, especially users of the Crescent, must be educated about the basic ecology of the salt marsh ecosystem, the role it plays in the food chain, and the importance it has in connection with the birdlife which now inhabits the Crescent.

Finally, discussion must be started between the various groups and individuals that have an interest in the future of the Emeryville Crescent. Ideas and recommendations need to be discussed among the different groups, and the priorities of each group must be shared.

REFERENCES CITED

Bailey, Stephen F., Museum of Vertebrate Zoology and Golden Gate Audubon Society, pers. comm., 1982.

Bodega Bay Institute, 1978. The Crescent, an environmental assessment of the Emeryville Crescent, for Golden Gate Audubon Society, 97 pp.

Brenner, Lynn, Parks Design Section Manager, Parks Design Section, pers. comm., 1982.

California Department of Parks and Recreation (DPR), 1982. East Bay Shoreline Feasibility Study, 61 pp.

East Bay Regional Park District, 1973. Master Plan, 1980, 48 pp.

Feelie, Lee, March 11, 1973. The Peoples Art Gallery. California Living Section of San Francisco Examiner, pp. 18-22.

Harvey, H.T., R. Gill, H.L. Mason and T.W. Wooster, 1977. The Marshes of the San Francisco Bay - Their Attributes and Values, for S.F. Bay Conservation and Development Commission, 156 pp.

Koos, Peter, Principal Planner, East Bay Regional Park District, pers. comm., 1982.

Sommer, Robert, 1975. Street Art: N.Y. Links, 66 pp.

__________, 1979. Mudflat Sculpture: Davis, Library Associates of the University Library, University of California at Davis, 17 pp.

Wakeman, Nancy, Senior Planner, BCDC, pers. comm., 1982.

Chapter 4

THE BRICKYARD

Debbie Robinson

The Brickyard (see map, p. vi) has been recommended as a first priority for acquisition and recreational development by the State Department of Parks and Recreation (DPR). The Brickyard is attractive because it is conveniently located near the Berkeley Marina with good access by public transportation, commands a view of San Francisco Bay, has 4,500 feet of bay frontage and is fairly flat and developable (DPR, 1982).

The land is currently owned by Santa Fe Land, Inc., a private concern. The State Coastal Conservancy (CC) has approached Santa Fe representatives to begin negotiations for purchase of the Brickyard (Brand, 1982, pers. comm.). CHNMB, a consulting firm hired by CC, has made a preliminary estimate of $2,500,000 (approximately $10,000 per acre) for acquisition and $2,000,000 for recreational development of the parcel. This brings the estimated total for purchase and development of the Brickyard to $4,500,000, the amount to be allocated for the shoreline park in DPR's fiscal year 1982 budget (Legarra, 1982, pers. comm.).

The public sector, as well as various agencies concerned with the development of an East Bay shoreline park, has varying priorities on specific sites and types of development. Most concerned groups are interested in the purchase of the Brickyard as a first step toward the park. However, there are conflicts and indecision over what the land should be used for, where the money for purchase and development will come from and which agency will make the final decisions on purchase, development and management of the parkland.

Site Description

The Brickyard is an interestingly-shaped, 27-acre parcel of land located at the southwest corner of the intersection of University Avenue and Frontage Road in Berkeley (FIGURE 1). A prevailing wind blows from the south, west and southwest. The wind is heaviest during the summer months (DPR, 1982). Strawberry Creek drains into a small cove which has a sandy beach. A peninsula running parallel to Interstate 80 creates an embayment at the north end. The western shore of this embayment is very steep, but the slope is more gradual along the north and east shores.

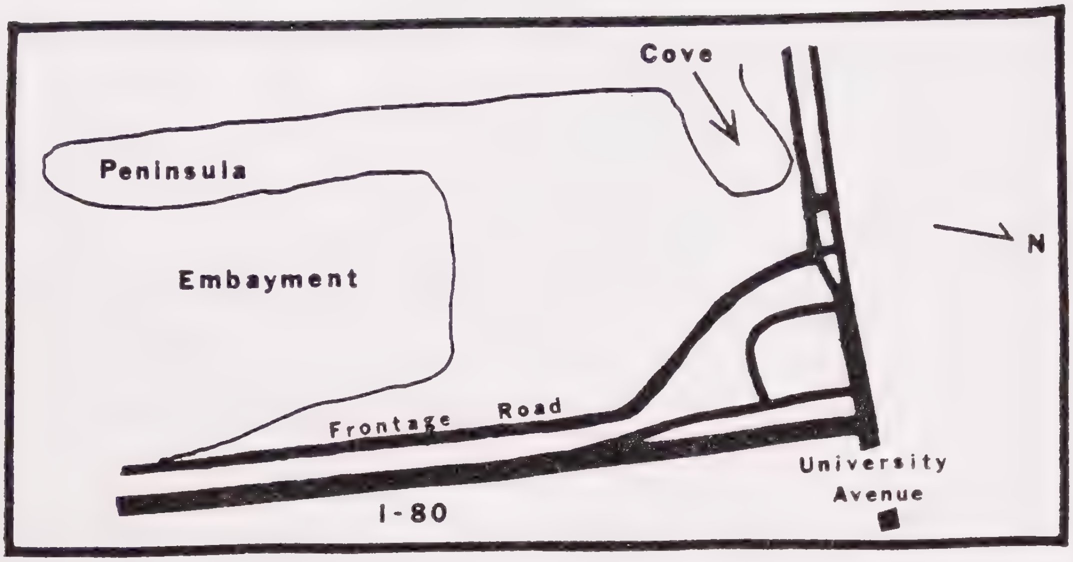

FIGURE 1. The Brickyard.

At low tide the Brickyard is bordered by an extensive mudflat. The embayment and cove empty, providing clam and mussel habitat, as well as an excellent feeding area for shorebirds.

The major portion of the Brickyard is flat and raised above the level of San Francisco Bay approximately 3 meters. The northeast corner and several roads running through the land remain unvegetated. Large freshwater puddles form here during the rainy season. The peninsula has been colonized mostly by weeds, grasses and broadleafed plants, including thistles, mustard, curly dock and fennel. Shrubs, such as coyote bush, make access to parts of the shore along the peninsula difficult. An endangered plant species, Cordylanthus mollis, has been found at the tip of the peninsula (Roberts, pers., comm., 1982). Some freshwater marsh plants such as cattails, as well as patches of iceplant, are present on the Brickyard.

Much of the Brickyard is covered by rubble consisting of old bricks, pieces of tile floors, broken sidewalks and curbs, old pieces of wood, wire and miscellaneous trash. Along the shoreline the pieces of cement are covered with algae. The rubble provides a home for many animals, including gophers, jackrabbits, rats and small birds.

People have left old furniture, trash, beer bottles and remains of picnic lunches at the Brickyard. The beach at the cove is particularly littered. The

University Avenue storm drain and Strawberry Creek empty into this cove, bringing polluted water and debris from city streets. The water here has a high coliform count resulting in contamination of clams and mussels in the area (see paper by Mirtha Ninayahuar). The beach usually has at least one dead rat or bird on it. It is unknown whether the deaths are attributable to pollution or some other cause. In either case, the carcasses are unsightly and unhealthful.

History and Current Uses

The Brickyard was formed from clean fill, that is, dirt was used to create the land rather than garbage (Manning, pers. comm., 1982). It subsequently became a dump for old building materials, torn up sidewalks, and discarded bricks until 1970, when the Bay Conservation and Development Commission (BCDC) banned further landfill there (Urban Care, 1976). The land is currently leased by Santa Fe Land, Inc., to Napa Excavators (Manning, pers. comm., 1982). These companies use the land for temporary storage and cleaning of brick and engineering soil. The north-eastern corner of the Brickyard is leased by a produce vendor. A houseboat of sorts is in the embayment, apparently without a permit from the City of Berkeley or the landowners (Neasbitt, pers. comm., 1982). It appears that someone is currently living in the structure.

Although there are "No Trespassing" signs around the Brickyard, people are often seen using the area for unstructured recreation. Our class survey (see paper by Grant Edelstone) revealed the following uses: collection of Daphnia from fresh-water ponds to be used as food for an exotic fish collection, fishing, dog walking, clamming, birdwatching, walking and general "hanging out" and drinking.

Development Issues

Although DPR is considering providing funds for the purchase of the Brickyard, it is not clear that the state will make the final decision on acquisition and development, or even manage the resulting park. City and state agencies, private citizens and interest groups will have input on recreational uses for the area. TABLE 1 summarizes the suggested uses for the Brickyard, indicating which organizations support the various possibilities. Those marked CHNMB represent suggestions brought forward by the public sector at Coastal Conservancy workshops. The ultimate decision on development will be affected by the City of Berkeley through its zoning powers (Brand, pers. comm., 1982). (See Mary Hagman's paper on zoning for a discussion of this issue). Peter Koos of East Bay Regional Park District (EBRPD),

RECREATIONAL USES

Visitors'/Nature education center	BOR, CHNMB, DPR
Birdwatching platforms	CHNMB
Preservation of mudflats for wildlife	CHNMB
Wade/swim area	DPR, EBRPD
Clamming	CHNMB
Fishing piers	BCDC, CHNMB, CITY
Small boat launch	CHNMB
Windsurfing facilities (showers, dressing rooms)	CHNMB
Grassy area/playing field	CHNMB, EBRPD
Kite flying	CHNMB
Open space	BOR, CDF&G, CHNMB, DPR
Unstructured recreation	CHNMB
Children's playground	ABAG
Restrooms	CHNMB, DPR
"Basic" amenities (trash cans, benches, fountains)	BCDC
Interim car/tent/RV camping	CHNMB, DPR
Parking	CHNMB, DPR
Par course	CHNMB
Sunbathing area	EBRPD
Community garden	CHNMB
Berkeley Beach	CHNMB
Unbroken stretch of shoreline park from Albany to Emeryville	CHNMB, CITY, DPR, SSFBA
Access trail to shoreline for jogging, biking, walking	BCDC, CHNMB, CITY, DPR

COMMERCIAL USES

Boat rental	DPR
Concession stand	ABAG, CHNMB, DPR
Restaurants	CITY, DPR
Small shops	CITY
Aquabusiness (commercial clamming)	CHNMB
Commercial development as a trade-off for recreational development elsewhere	CHNMB, CITY

REFERENCES

ABAG	Association of Bay Area Governments, 1973
BCDC	San Francisco Bay Conservation and Development Commission, 1978
BOR	Bureau of Outdoor Recreation, 1977
CDF&G	California Department of Fish and Game, 1979
CHNMB	CHNMB Associates, 1982
CITY	City of Berkeley, 1982
DPR	California Deaprtment of Parks and Recreation, 1982
EBRPD	East Bay Regional Park District, 1976
SSFBA	Save San Francisco Bay Association, 1981

TABLE 1. Suggested Recreational and Commercial Uses for the Brickyard by Public Agencies and the Private Sector.

which may ultimately have a hand in development and management of the park, has made it clear that long-range planning and economics play very important roles in the park proposal. Acquired land may sit undeveloped until more funds are found. In addition, initial park development may be unattractive and undermanaged until the public becomes aware of its existence and starts to use it.

The Bay Conservation and Development Commission (BCDC) is playing a passive role in initial development plans. The Commission's emphasis is on assuring public access to the shoreline, regardless of the type of development. BCDC's Public Access Plan for San Francisco Bay finds specifically that the shoreline from University Avenue to Emeryville should have an access trail as well as undisturbed fishing areas. Rights-of-way should be developed with basic public amenities such as trash cans, benches and drinking fountains. The power of BCDC is manifested in its permit process. In order to be issued a permit, a proposed project must demonstrate that public access to the shore is provided and even enhanced (Wakeman, pers. comm., 1982).

Decision-making by any public agency is strongly influenced by the opinions of the public sector, as represented by individuals, as well as citizens' organizations. Among those groups who have thus far contributed their opinions in public meetings and Coastal Conservancy (CC) workshops are Berkeley Beach Committee, Save San Francisco Bay Association, CAl Sailing Club and the California Native Plant Society.

DPR presented, in its preliminary feasibility study, a plan for development of the Brickyard which emphasizes immediate grading and landscaping to provide pathways, picnic areas, parking spaces and an orientation center. Water-related uses such as wading, swimming and clamming were also suggested. DPR reasons that the sooner the area is made attractive to the public, the sooner public interest can be raised in support of further development of a shoreline park from Albany to Emeryville.

Some of DPR's suggested uses for the parcel are inconsistent with the desires of other concerned organizations. For instance, in order to promote windsurfing at the Brickyard, the embayment would have to be dredged. This would create an added expense and destroy a valuable mudflat. The Cal Sailing Club expressed no interest in windsurfing in that area. Representatives of the club present at DPR's public meeting in Berkeley instead stressed the need for better access to the water in the North Basin, on the north side of the Berkeley landfill.

The City of Berkeley does not favor use of the Brickyard solely for open space (Neasbitt, pers. comm., 1982). The City feels that the Marina and proposed

North Waterfront Park will provide adequate open space, unstructured recreation area, windsurfing and boating opportunities and sheltered picnic areas. The Brickyard, according to the City, is not a suitable place for many recreational activities. It is too noisy, unsheltered from the wind, and the direction of the wind and extensive mudflats at low tide make it inconvenient for windsurfers and boaters. It would most useful and economically feasible to develop the Brickyard into a combination of recreation and light business to draw people to the water-front. Restaurants and/or small shops along with a fishing pier would be appropriate. People attracted to the shops would subsequently discover the other recreational opportunities nearby.

The Berkeley Beach Committee would like to restore a beach to the stretch of waterfront between University and Ashby Avenues. This plan would have an effect on the Brickyard since it includes removing the Brickyard peninsula in order that the embayment may become part of the gently curving shoreline (Manning, pers. comm., 1982). This proposal requires further study and is addressed in the papers by Don Bachman, Peter Gee and Linda Goad.

Regardless of the specific type of recreational development, certain priorities must be considered for a successful park. Studies show that factors which prevent people from using parks in urban areas include poor access, insufficient parking, over-crowding, lack of variety of activities, general unsafety and high entrance fees (ABAG, 1973; Bureau of Outdoor Recreation, 1977; EBRPD, 1976). Other factors come in to play specifically in the Brickyard area. Constant noise from the freeway and 7-10 mile per hour winds can be disturbing. Water quality in the cove is poor (see studies by Bessie Lee and Mirtha Ninayahuar), a deterrent to water contact activities and clamming. All of these problems can and should be alleviated by careful planning prior to development of the park.

Conclusion

I feel it is important for the Department of Parks and Recreation to purchase the Brickyard. Due to its bayside location, I see it as a prime spot for its current owner, Santa Fe Land, Inc., to propose commercial development. In light of the plan for a continuous East Bay shoreline park, and the need for more recreational open space in Berkeley (see paper by Grant Edelstone), it would be valuable for a public agency to prevent private commercial development by purchasing and reserving this land for public recreational use, with free access to the shore. Also, in light of the limited amount of funds currently available the

Brickyard is a realistically small and obtainable parcel of land with which to start. In order to raise more money for the park it will be necessary to rally public support. It seems feasible that the Brickyard could be used to attract people to the shoreline and educate them on the need for their active support.

The City of Berkeley and DPR need to work together on the proposed shoreline park. However, it appears that they are already working at cross purposes. DPR states in the feasibility study that the City welcomes cooperation and assistance from DPR in further development of <u>its</u> (the City's) planned park on the Berkeley landfill. But many suggestions submitted by DPR, such as development of camping facilities and preservation of open space at the Brickyard, haven't even been studied, much less approved, by the City. It will be necessary at some point for representatives of the two entities to define clearly their goals and create methods of working together on the parks.

DPR's proposed uses for the Brickyard are compatible with the Brickyard's size and location. Although the City of Berkeley is not enthusiastic about camping on the shoreline, I am. It was pointed out at DPR's public meeting that people already camp illegally at the Marina and in local parks. This could be prevented by making facilities available and having park employees police the camp area. Trails for biking and jogging, picnic, areas, fishing areas and general open space are all suitable and there is a demonstrated need. Landscaping should not be too manicured. A representative of the California Native Plant Society present at DPR's public meeting stressed that native plants and shrubs should be used to promote a feeling of undeveloped open space.

I am not opposed to light commercial development on the Brickyard, especially if it makes the shoreline park economically more feasible. However, the projects chosen should relate directly to recreation; a snack stand and small boat rental are more attractive to me than a complex of small shops and a restaurant.

Prior to actual planning for a park on the Brickyard, a detailed study should be made of its history and the potential for meeting outstanding recreational demands such as those listed in TABLE 1. If any buildings will be constructed, the condition of the landfill must be determined. Since BCDC prohibited further fill after 1970, a fair amount of subsidence should already have occurred. In the event of an earthquake, however, the ground could settle even more, causing structural damage as well as human injury (see paper by Mary Dresser).

Certain improvements must be made before specific recreational uses for the area are implemented. Pedestrian access should be improved (see paper by Dexter Chan). A sound barrier should be constructed near the freeway, and protection from the wind should be provided for picnic areas. However, planners should be careful not to simply create a mound of dirt as a windbreak, as this would obstruct the view of the San Francisco Bay. Trees and bushes could be planted around the picnic area to slow the wind down. If water contact is anticipated, the water quality must be improved, especially in the cove. The University storm drain, which empties into the cove, must be screened and coliform levels kept under control. Planners should also maintain a sensitivity to wildlife habitat, bearing in mind the value of the Brickyard to an endangered plant species and shorebirds which feed on surrounding mudflats.

Overall, the Brickyard has enormous potential for recreational development and should be purchased as soon as possible as a first step toward a complete East Bay shoreline park.

REFERENCES CITED

Association of Bay Area Governments (ABAG), 1973. Recreation Preferences of Minority People in the East Bay Area: A Pilot Study: Berkeley, CA, ABAG, 146 pp.

Brand, Peter, Project Analyst, California Coastal Conservancy, personal communication, April, 1982.

Bureau of Outdoor Recreation, Pacific Southwest Regional Office, 1977. National Urban Recreation Study: Denver, CO, National Park Service, NPS 1217, 154 pp.

California Department of Fish and Game, 1979. Protection and Restoration of San Francisco Bay Fish and Wildlife Habitat, volume 1, 12 pp.

California Department of Parks and Recreation (DPR), April, 1982. East Bay Shoreline: Feasibility Study, 61 pp.

CHNMB Associates, 1982. Draft East Bay Shoreline Report for the State Coastal Conservancy, San Francisco, CA 21 pp.

City of Berkeley, 1977. Master Plan, Waterfront Section, pp. 77-78.

East Bay Regional Park District (EBRPD), 1976. The EBRPD Need and Demand Survey, Project #95026, San Francisco, CA, 14 pp.

Koos, Peter, Principal Planner, East Bay Regional Park District (EBRPD), personal communication, April, 1982.

Legarra, Bonnie, Project Analyst, California Department of Parks and Recreation, personal communication, April, 1982.

Manning, Curt, Chairman, Berkeley Beach Committee, personal communication, March, 1982.

(continued)

REFERENCES CITED
(continued)

Neasbitt, Walt, Supervisor, Berkeley Marina, personal communication, April, 1982.

Roberts, Mariko, Landscape Architect, California Department of Parks and Recreation, personal communication, March, 1982.

San Francisco Bay Conservation and Development Commission (BCDC), 1969. San Francisco Bay Plan Supplement, San Francisco, 572 pp.

__________, August 2, 1978. Public Access Plan for San Francisco Bay. The Bay Shoreline Element Preliminary Findings and Conclusions. San Francisco, CA, pp. 22-28.

Save San Francisco Bay Association (SSFBA), Berkeley. Letter to Peter Dangermond, DPR, Sacramento, November 14, 1981.

Urban Care, September 1976. Conservation and Development on the Berkeley Bayfront: Concerns, v. 5, no. 1, 6 pp.

Wakeman, Nancy, Senior Planner, San Francisco Bay Conservation and Development Commission, personal communication, February, 1982.

Chapter 5

A SURVEY OF THE NORTH WATERFRONT PARK

Sharon D. Gray

Introduction

Since the early 1930's, Berkeley has been disposing of its solid waste debris by means of the sanitary landfill method. Licensed as a Class II dump (i.e., only clean domestic and city-wide refuse could be deposited; no hazardous or toxic wastes), the disposal area encompassed several dike and fill projects along the mudflats and intertidal areas of the Berkeley waterfront. By 1967, the Berkeley City Council had begun efforts to develop a preliminary land use plan in anticipation of the conversion of the sanitary landfill. The 90 acres of the Berkeley Sanitary Landfill is one of only three remaining areas suitable for park construction along the East Bay shoreline. The other two are privately owned by Santa Fe Land Co., Inc. Given the proximity and morphology of the garbage fill area, it has been generally agreed that, in terms of future utilization of the land, the area is best suited for unstructured, open space design. The ultimate goal of the City of Berkeley, in terms of the conversion, is to continue in the preservation of the unique and delicate ecosystem that is particular to the bay environment.

With the progression of time, and a series of actions involving the Berkeley City Council, the Bay Conservation and Development Commission, the U.S. Armp Corps of Engineers, and the Regional Water Quality Control Board, a preliminary concept of the landfill site was formulated. "The design included: (1) a wildlife refuge area, (2) development of a seven acre pond, (3) maximum public access to the surrounding water, and (4) features and facilities to enhance an unstructured recreational theme" (City of Berkeley, 1976, p. 5). Here unstructured is defined as a flat, open area meant for such activities as frisbee throwing and picnicking, versus the construction of basketball courts, baseball diamonds, or concession stands. The focus here is that these prerequisites would eventually take on visibility as three major zones (FIGURE 1): (1) a <u>Recreation Zone</u> - the most important of all three, because it is specifically meant for human utilization, as evidenced by its having the greatest accessibility; (2) a <u>Wildlife Zone</u> - nonstructural; meant to be

as close to the natural state as possible, as seen in the lack of pathways for human access, and fencing; this area to serve mainly as a wildlife refuge, especially for birds; (3) a Transition Zone - an area of transition between the recreation and wildlife refuge areas.

The uniqueness of the North Waterfront Park (NWP) plan is that it was designed to be monitored by a team of park design specialists, a group of five licensed landscape architects. This team now forms the Parks Design Section of the City of Berkeley. In spite of the fact that up until this point the entire project had been subject to obligations brought on by a host of regulatory and citizen action groups, in order to secure Corps of Engineers certification, there still remained room for the innovative design of a unique and imaginative design team.

Before any designs for the NWP project could be formulated, the compilation of a Land Use Plan, an Environmental Impact Report, and a Final Closure Plan for the dump were required. The Final Closure Plan was scheduled to have been submitted by March 15, 1982, with the actual closure of the site itself scheduled for approximately 1983-84. The Land Use Plan simply states how the land is scheduled to be utilized.

The EIR explains what effect the conversion will have on the surrounding physical environment. The Final Closure Plan is designed to insure that all parties responsible for the operation of the dump site comply with all state and federal rules and regulations for a Class II dump closure. Prior to these three steps, the Parks Design team was hired by the City of Berkeley to begin designing plans for the conversion of the 90-acre dump site to an unstructured recreation area.

Simultaneously, administrators of the Berkeley Parks Department, based at the Berkeley Marina, began work to generate funding for the NWP project. This was to be accomplished by means reflecting the least cost to the City of Berkeley, which has had " . . . zero funds available to cover the development of any new parks" (Brenner, 1982, pers. comm.). In essence, this meant that not only would external funding be essential, but also that the funding would have to be generated solely by the efforts of the Marina section of the Berkeley Park Department. When necessary, Marina-generated revenues are used for matching, dollar for dollar, these external sources of funding. Therefore, due to these factors and the large estimated cost of converting the park, plus the fact that the dump is still in operation today, it was decided that the best possible course of action would be to break the project up into a multiphased venture, based on a non-rigid timetable for completion. To date, designs have been completed for three projected phases. Each

phase encompasses from six to ten acres.

Upon examination of the diversity and complexity of the conversion process itself, it becomes clear that conversion is more than merely a question of financial support. This is true because the ultimate design of the project has to take into account not only the question of funding availability, but also a host of physical and social factors that will strongly determine the use rate after completion. Given this background, in terms of the entire conversion picture, my original inclination, to determine just the overall cost and worth of the conversion of the Berkeley sanitary landfill to an unstructured park for recreational use, evolved into an effort to contend also with the question of the actual "likelihood," in light of all of the details involved, of your and my ever seeing a completed 90-acre North Waterfront Park within our lifetimes. This report is an attempt to explore, and therefore clarify, some of the issues of the conversion that are important today. It is necessary to bear in mind here that these very issues could, in all likelihood, shift in some unforseeable manner over the next 5-10 years, hinging on such diverse factors as the policies and goals of our present Republican Administration.

The Costs of Conversion

In 1977, a conservative estimate of the total cost of converting the entire 90 acres of the Berkeley Sanitary Landfill to an unstructured park was figured at approximately $10,000,000. Today, the total budgeted costs for phases I, II, and III amounts to $1,320,000 (phase I = 10 acres at $520,000; phase II - 6± acres at $500,000; phase III - 6 acres at $300,000). This could be decreased to $1,206,000 if phases II and III were combined. In 1981, the above figures were submitted to the Waterfront Advisory Board, a citizen action group, by the City of Berkeley's Parks Design Section, as representing the NWP funding breakdown (see TABLE 1). These costs were projected to cover approximately 22 acres of development. Overall, the cost of developing amounts to an average of approximately $500,000/10 acres. Presently, complete funding has been obtained for phases I and II, while that for phase III is still in the process of acquisition.

To date, the landscape design for phases I-III is complete (FIGURE 1). All three have been designed as part of the Recreation Zone. Phase I was completed and opened to the public on 2/28/82. The simplest of all 3 phases in terms of design, the cost of phase I was concentrated mainly in the purchasing of wood planks, chips, sawdust, grass, and gravel, which was used to form a circular parking

BUDGETED PHASE I

Source	Amount	
Marina Op. and Maint.	$203,000	($67,000± expended Phase I)
LWCF	203,000	($203,000 expended Phase I)
Calif. License Plate Fund	250,000	($250,000 expended Phase I)
Total	$656,000	$520,000 for Phase I

BUDGETED PHASE II

Source	Amount	
LWCF	$250,000	Approximately $136,0-0 is carryover from original $203,000 budgeted for Phase I.
Marina	250,000*	
Total	$500,000	

PROPOSED BUDGED PHASE III

Source	Amount	
Proposition I	$300,000	No match required.

*NOTE: If the Prop I grant is approved, it can be used as the match for the Phase II $250,000 LWCF grant. Consequently, use of Marina monies for Phase II may not be necessary.

PROPOSED COMBINATION OF PHASE II AND III IF PROP I GRANT APPROVED

Source	Amount	
LWCF	$250,000	
Prop I	300,000	
Marina carryover	136,000	This amount may not have to be spent.
Total	$686,000	

TABLE 1. Funding Breakdown.

lot/vista point. "Phase II will be a six acre± site directly north of phase I (FIGURE 1). The project activities include grading and drainage, an irrigation system, soil preparation and landscaping, unstructured playfields, barbeque and picnic areas, pedestrian paths, and a maintenance building" (Public Works Dept., 1979, p. 3). The phase III area will be used solely for access. "Specifically, phase III will include: site grading and soil preparation; installation of an irrigation system; landscaping; construction of bicycle and pedestrian pathways; installation of benches, picnic areas, boulders, trash receptacles and barbeque facilities" (Allen, 1981, p. 2). Parking facilities will not be developed in the phase III area. Also, no pathways will be provided solely for bicyclists. In general, "park pathways will be designed to accommodate safe use by bicyclists,

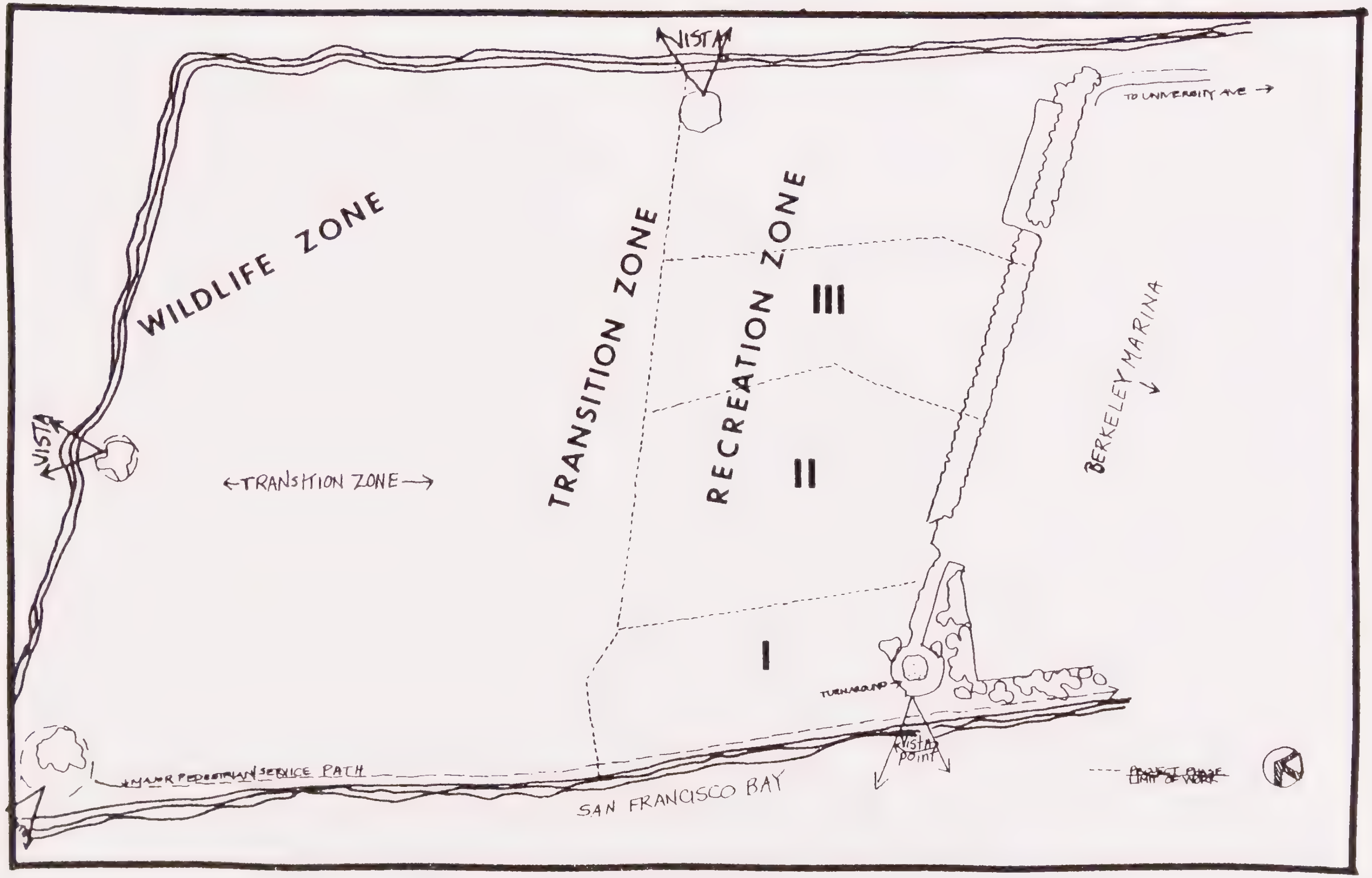

FIGURE 1. North Waterfront Park.
Source: Allen, 2/28/81.

pedestrians and service vehicles" (Public Works, 1979, p. 3). There is no exact spending budget available for any of the three phases, only a funding budget breakdown.

During this time of post Proposition 13, the City of Berkeley is experiencing some difficulty in obtaining the financial resources necessary to complete the transformation of its 90 acre refuse disposal site into a public park. The answer for the City of Berkeley has been the cost-effective approach; or, in other words, cutting corners whenever possible.

In order to expand beyond these limits of production, it was suggested that phases II and III be combined. This was scheduled to save as much as $114,000 in construction costs alone. The utilization of the California Conservation Corps has also been scheduled, in order to further decrease the cost of construction. Finally, the ultimate cost-effective item, and probably the most important, is exemplified in the area of park production itself. "The city of Berkeley is one of the only cities in the state of California with a Parks Design Section, a team of five licensed landscape architects, whose sole function is to design and construct public open spaces. Because of this type of in-house production experience, Berkeley has the ability to implement construction projects, from preliminary design through final inspection, in an efficient and timely fashion. This kind of in-house capability has made Berkeley successful in bringing its projects in on schedule and within set budgets" (Allen, 1981, p. 4).

Funding Acquisition for Conversion

The theoretical yields for the funding breakdowns appear very concise on paper, but where does this funding actually come from? Presently, the City of Berkeley relies on five means of funding for the park conversion. They are: the Environmental License Plate fund, money made available from the 1980 State Park Bonds Act Initiative (Proposition 1), the Land and Water Conservation Fund (LWCF), the Marina Waterfront Development Fund, and the Marina Operation and Maintenance Fund. It has been calculated that these five resources should supply all funds necessary for completion of the NWP project.

The Environmental License Plate Fund is an ongoing state no-match grant. This means that individual cities and counties can apply for the money available without having to pay anything in return, in terms of hard cash or services. The City or County can either apply directly to the Department of Motor Vehicles for the grant or through an assemblyman. In 1981, Assemblyman Tom Bates acquired $250,000 by

this means for use in phase I. Because the application was late this year, this grant will not be available for utilization, in the completion of phase III. The Environmental License Plate Fund is to be used in areas that enhance the environment that we live in. It is made available from the revenues generated by the California Department of Motor Vehicles in the sale of personalized vehicle license plates.

The State Park Bonds Act Initiative of 1980 (Proposition 1) made available the bond sum of $100,000,000, which was designated to be used in the development of state shoreline parks. The money generated by the sale of these bonds goes toward the acquisition of State Parks. It is a no-match fund. In August of 1981 the City of Berkeley applied to the State Coastal Conservancy, which is responsible for administering Proposition 1 funds, for $300,000 of this bond money. This amount is budgeted into the funding breakdown for the completion of phase III (TABLE 1). As of yet, there has been no reply from the SCC.

The LWCF is federally administered by the State Department of Parks and Recreation. From there it goes to local city and county agencies. Started in 1965, the LWCF is a part of the Heritage and Conservation and Recreation Service. It is a 25 year program to be used for either the acquisition or the development of parks, but not both. This fund is a 50-50 cash match grant. If the party applying requests $200,000, then it has to be able to match that amount. It is a reimbursement-only grant, to be awarded only after completion of a major phase of construction. $203,000 of this fund was expended for phase I, while $250,000 was utilized in phase II (TABLE 1). In spite of past successful usage of this fund, the future of the LWCF is uncertain, because it has become virtually nonexistent under the present administration.

The Marina Waterfront and Development Fund is generated by garbage dumping fees collected from private citizens. This fund is mainly used for supplying the basics of construction, such as preliminary coverings and gratings. It is also used to pay the dump operator's salary. Part of the operator's duty is also to make sure that the wastes disposed of at the site are organized in a manner best suited for the conversion design of the landscape architects.

The Marina Operation and Maintenance Fund (MOMF) is presently used as a basis for the acquisition of grants that require matching. There can be no matching without this fund. The fund has been in operation since the early 1960's. It is generated from revenues collected at the Marina. The two sources of revenue there are berth rentals, and a percentage of the gross revenues collected from concessions.

These sources amount to approximately $2,000,000 yearly. Although the idea is to obtain money from outside sources whenever possible, this fund is the final fall-back, in terms of resource availability, for any interests of the Berkeley Parks Department operating out of the Marina. Without this fund, there could be no park conversion. Within the forseeable future, the money generated by this fund should continue to be enough to support completion of the NWP project.

Summary of Additional Factors Affecting Conversion

As stated in the introduction, the physical and social aspects of park development can play important roles before and after conversion, respectively. The physical factors depend on construction, for the most part. An example of this type of application is seen in the following quote: "The NWP work accomplished for phase I already serves as a model for other bay jurisdiction, and especially for those which must grapple with the considerable problems related to garbage fill. Work undertaken in the following areas has made Berkeley a resource for other bay cities: testing and growing plants on site to accommodate harsh site conditions; special path-paving specifications to accommodate soil settlement; taking special steps to design mounding for wind protection by using a lob to run wind tunnel tests on a 50-scale site model; and special planting design intended to reflect existing California coastal successional plant communities" (Allen, 1981, p. 4).

Between 1976-77, improvement such as the construction of dikes containing impervious seals were added to guard against leachate spilling into the surrounding bay environment. These dike improvements have been approved by the Regional Water Quality Control Board. To date, there is no problem with methane, because the park has been designed to withstand exposure to the types of organics found in domestic garbage. Minimization of organic-containing household refuse tends to minimize the production of methane. Given these precautions, the physical questions of leachate and methane exposure is " . . . not now, nor will it be a problem in the forseeable future" (Baughman, pers. comm., 1982). Also, the slopes of the landfill have to be at least 3%, in order to prevent occurrences such as landslides and the accumulation of surface run-off.

Compaction is also a key factor in the physical appearance of a landfill. Before the early 1970's, Berkeley was not compacting its refuse debris at the sanitary landfill site. This was because compacting meant extra costs. The outcome of this practice was an increase in the rate of differential settling. Consequently,

beginning in the early 1970's, with the recommendation of engineers, Berkeley began to utilize the compaction method. Because settling at a landfill cannot be totally eliminated over time, 3-5 inch settling is allowable. Today, the City of Berkeley can worry less about the problem of greater settling, because compaction decreases the probability of its occurrence.

The final closure plan for the dump requires a covering of 3 feet of clean soil. This has proven to be somewhat of a major problem in itself. The soil for the covering is usually acquired from construction companies, whenever they are constructing and therefore digging up new sites. The construction companies at one time considered all the excess dirt a burden, so they were glad to give it away to anyone who would take it. Today, with this soil necessary for jobs such as landfill closures, there has been increased competition for it. Consequently, not only is one forced to wait on construction in order to obtain the necessary soil, but in addition, all of the competition has decreased its availability and increased the price.

The ultimate physical question to be dealt with, in terms of the conversion design, is that of the earthquake factor. If the Bay Area were hit by a major earthquake, the present-day landfill area along the East Bay shoreline would be subject to immense shaking. The outcome of this type of earthquake would more than likely mean large-scale damage to all landfill structures. Therefore, the question of whether the site is suitable for maintaining the support of any structures, large or small, becomes a most important one. The solution to offset large-scale damage to any structures has been to construct them on either pilings or floating foundations (see Mary Dresser's paper).

In contrast to the aforementioned physical restrictions, the social questions engulfing the conversion process pertain mainly to the question of urban need and demand. People in urban areas, such as Berkeley, enjoy having access to open-spaced, unstructured recreation areas. "The primary urban recreational need . . . is for the establishment of more parks (in the sense of an unstructured public open space suitable for all ages, for socializing as well as recreating) within the community or neighborhod" (Bureau of Outdoor Recreation, 1977, p. 5).

Aesthetic value, as well as accessibility, will determine who will take the time to visit a NWP after its completion. To this end, the design of the NWP includes several vista points allowing for a panoramic view of the bay environment (FIGURE 1). The accessibility of the park itself is also not a pertinent problem, because there is easy access to the Berkeley Marina, via AC Transit,

from most points in the East Bay. " . . . NWP development will create totally new access opportunities for Bay Area residents. Until recently, public access to this refuse disposal site was prohibited due to hazardous site conditions. New recreation opportunities such as strolling, jogging, sitting, picnicking, viewing and bicycling along the waterfront are being developed through the design and construction of the NWP. There will be 1.4 miles of unobstructed access along the site's perimeter" (Allen, 1981, p. 3). The NWP project has been recommended by the BCDC as " . . . an exceptional site in the public access supplement to the San Francisco Bay Paln and is also consistent with the public access design guidelines of BCDC and Coastal Conservancy" (Allen, 1981, p. 3). If present use of the Berkeley Marina is any indication, then it can be anticipated that the use of the completed NWP will be substantial.

Conclusion

At first glance, the process of conversion seems to be burdened with details, details that engulf more than the physical and financial aspects. Upon analysis, it becomes clear that it is not only the basic steps of construction that are involved, but also factors such as funding, a required settling time of 5-10 years for 30 acres of the dump still in use, and the availability of clean soil that determine the longevity of the conversion process.

At the current stage in development funding is a major problem, in that sometimes it can amount to a noncohesive series of events; noncohesive in the sense that the City of Berkeley virtually doesn't know where its next funding dollar will come from. This is exactly what is having a large effect on completion of the NWP project. The present neoconservative trend that we as a country are experiencing is putting a squeeze on programs, such as those that are environmentally or socially oriented, those that don't tend to promote immediate and tangible results. Or, in comparison, not as immediate and tangible as the results of tax cuts or the purchasing of ever-increasing military weapons. Given this atmosphere, we have seen the virtual abolishment of the LWCF, although at its inception in 1965 it was intended to be a 25 year program, and programs similar to it. In this wake, the strategy has been to consider alternative means of attaining the same end. One possibility is currently underway. That is a proposal by the State Department of Parks and Recreation to place the NWP under its jurisdiction, thereby creating another State park. This would be acceptable to the City of Berkeley, because they would just like to see the completion of the park as they had originally planned it.

Even if all of the previously mentioned factors were ideal, this still wouldn't guarantee rapid completion of the project. This is because the NWP project is presently not the only concern at the Berkeley Marina. The Marina is presently focusing on the erosion of not only its sewage system, but also that of its breakwater. Certainly, it becomes evident why these complications would be of more immediate concern. The sewage problem itself could amount to $500,000 easily.

These complications have caused a shift in focus, away from the NWP. In other words, the priority of the NWP has been lowered indefinitely. This has served to slow down its rate of completion.

In spite of the details, we must bear in mind that from an ideological standpoint, the NWP project is the best alternative, realistically, for utilization of Berkeley's solid waste disposal area after its closure. In addition, the NWP would also contribute to the beauty of an East Bay Shoreline Park. In light of these facts, and the inherent complications involved, what is the likelihood of ever witnessing the completion of the 90-acre NWP project? A conservative estimate might be something like . . . maybe by the year 2000.

REFERENCES CITED

Allen, Wise E., 2/28/81, City of Berkeley's application for North Waterfront Park, phase III (NWP III) development funding, 8 pp.

Baughman, Mike, Project Manager, Department of Public Works, City of Berkeley. Personal communication, 5/27/81.

Brenner, Lynn, Manager, Parks Design Section, City of Berkeley. Personal communication, 4/12/82.

City of Berkeley, 1976. Preface to Berkeley Land Use Plan, 9 pp.

Hemmans, Jim, Landscape Architect, Parks Design Section, City of Berkeley. Personal communication, 4/12/82.

Bureau of Outdoor Recreation, 1977. National Urban Recreation Study: San Francisco/Oakland/San Jose. National Parks Service, 154 pp.

Parks Design Section, City of Berkeley, 1981-NWP funding breakdown: phases I-III, 1 p.

Public Works Department, City of Berkeley, 1979. Request to authorize City Manager to submit, and execute if approved, an application for a 1979 Land and Water Conservation Fund grant for NWP-phase II.

Rogers, Chuck, Senior Administrative Analyst, City of Berkeley. Personal communication, 5/26/82.

Chapter 6

URBAN STREAM RESTORATION IN THE EAST BAY

Arthur Molseed

Introduction

Preservation of natural areas within urban cities has become a policy goal of most concerned resource agencies. Government agencies in the San Francisco Bay Area need to be particularly sensitive to this issue because of the relative scarcity of these natural pockets in this densely populated part of California. Natural areas are important; they contribute to the mental well-being of urban residents and make the city a healthier place to live (Dearinger, 1968).

The East Bay was once a place rich in natural resources, including many quiet streams which originated from springs in the foothills, meandered across the riparian bay plain, and emptied into valuable marshland along the East Bay shoreline (Shipounoff, 1979). But, over time the East Bay has become heavily urbanized, and Berkeley has become one of its most highly developed cities. In this city, industrial development, as well as the majority of the population, is concentrated on the bay plain. Needless to say, much of the natural beauty that once existed has been destroyed. There is, today, a severe shortage of natural open space within the city of Berkeley. Available open space is far below the standard recommended by the State of California for metropolitan regions (City of Berkeley, 1977). Even many of the creeks have disappeared from the landscape; fifty percent of them have been placed in underground conduits (FIGURE 1). Unfortunately, very few of the stream reaches remaining above ground can still be enjoyed by Berkeley residents. For the most part, they pass through private property or are behind barriers. Worse still, the creeks have been neglected and the natural stream environment has greatly deteriorated. Restoration of the streams is possible and should be done. In addition to making Berkeley a healthier city, restoration could provide additional natural open space for public benefit. Development of an East Bay Shoreline Park project is an ideal opportunity to rescue and rehabilitate portions of the streams near the shoreline.

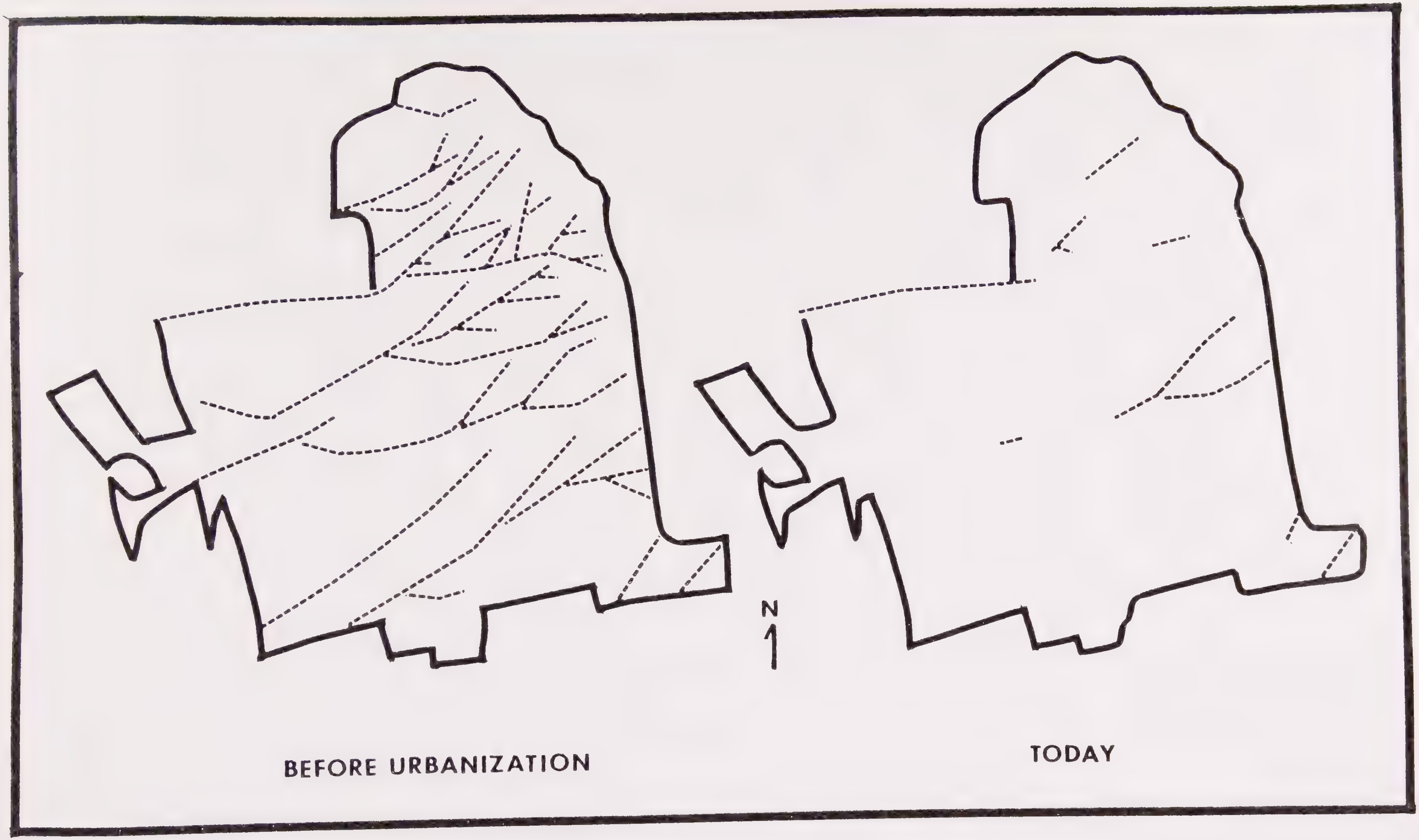

FIGURE 1. Berkeley's Stream Network Before and After Urbanization.
Source: Berkeley Master Plan, 1977

Historical Background

Berkeley was one of the first cities in the East Bay to develop, and it has become one of the most heavily urbanized. Development of the city began during the second half of the nineteenth century. Initial growth in the eastern foothills followed the establishment of the University of California and the School for the Deaf. At about the same time, construction of the railway spurred industrial and residential development on the western bay plain. The population of Berkeley began to grow rapidly after the turn of the century, much of this growth occurring after the 1906 earthquake. The population reached 40,000 people by 1910. By 1930 it had climbed to 82,000 (City of Berkeley, 1977).

This rapid development changed the hydraulic properties of the watershed. To control the flooding which occurred after deforestation along streams and the construction of impervious land surfaces robbed the landscape of its ability to store rainwater, the natural stream channels were redesigned. Channelization, the flood control method of choice, was used to increase the water-carrying capacity of the channels (Shipounoff, 1979). Meandering streams were straightened. Riparian vegetation was removed from the banks, and the creeks were lined with concrete. Floodplain management, a planning measure designed to control development in flood prone areas, was rarely practiced during the urbanization of Berkeley. As a result, most of the available land was developed, especially on the bay plain where it was easiest to build. Many stretches of creeks were placed in underground conduits to make even more land available for development. In 1922, construction of the University of California's Memorial Stadium covered a large section of Strawberry Creek and Canyon (Shipounoff, 1979). None of the flood control projects in Berkeley were federally sponsored; all channel alterations were carried out by local interests (U.S. Department of Housing and Urban Development, 1976).

During this period of development the water became increasingly befouled as well, chasing away the salmon that used to spawn in the upper reaches of the streams. Garbage was frequently thrown into the channels. Contaminants from nearby septic tanks leached into the waters. Finally, in 1951 a bond act was passed to authorize construction of a modern sewage treatment plant which reduced the threat of sewage contamination. But the stream water is still polluted by storm runoff. Today, eighty percent of the storm draings enter the stream network at some point. Sadly, the many aesthetic, recreational and natural values of the streams were not recognized during Berkeley's development.

Importance of Streams in the East Bay

Providing open space and natural areas in cities is one important use of streams in the East Bay, but they also serve, or have the potential to serve, many additional functions. These include a number of beneficial biological and physical processes which enhance the surrounding environment. Perhaps the most important is providing a continued supply of nutrients to marshland along the East Bay shoreline (Eimoto, 1982, pers. comm.). The streams are also an important source of groundwater recharge. Lining stream channels with concrete prevents the percolation of water into the soil and precludes this function (Tri-Cities Citizens Advisory Committee, 1973).

Riparian vegetation, including such native tree species as willow, buckeye, and bay can still be found along protected reaches of Berkeley streams. Codornices Creek still has thick native vegetation in many places (Albany Land Use Committee, 1977). Acre for acre, riparian vegetation is the most valuable wildlife habitat in California (Calif. Dept. of Water Res., 1981a). The root systems of this vegetation serve to stabilize the banks and prevent erosion. Vegetation also absorbs precipitation and runoff, purifying it in the process before it enters San Francisco Bay. Vegetation improves air quality by consuming carbon dioxide, releasing oxygen and by removing chemical pollutants from the atmosphere (Pimentel, 1979). Trees act as noise buffers and reduce noise pollution. Plants hanging over the stream shade the water, making it a more hospitable environment for wildlife (Migel, 1974).

Streams are also an aesthetic asset for private property owners in Berkeley. They have potential as nature study areas, both for education of schoolchildren and use in scientific research (Tri-Cities Citizens Advisory Committee, 1973). Restoration of streams in Berkeley would increase the already important contributions they are making.

Restoration

Individuals and private groups in the East Bay have been working for over a decade to restore local streams. Creek cleanups to clear litter and debris from various streams are held every several months and city residents are invited to participate. A neighborhood group, Los Amigos de Codornices, which has dedicated itself to preserving local streams, formed several years ago.

More recently, some government agencies have become involved in creek preservation. In 1976 the city of Albany authorized a study which resulted in the adoption of Albany's Creek Restoration Plan. This document outlined the existing conditions of Albany's creeks and recommended a plan to protect and preserve them (Albany Land Use Committee, 1977).

The city of Berkeley has recently taken action to restore a section of a local stream. Plans have been drawn up by the city's Parks Design Department to open and restore a stretch of Strawberry Creek as it crosses under the former Santa Fe Railroad right-of-way. This park will serve a neighborhood which greatly needs open space. Construction of the park should be completed by the end of 1982 (Wolfe, 1982, pers. comm.).

The California Department of Water Resources also recognizes the importance of urban streams. In 1976 this agency established the Urban Streams Cleanup and Restoration Program to encourage and partially fund stream improvement in California (Calif. Dept. of Water Res., 1980). The Department has established two goals for urban stream restoration in major metropolitan areas of California. These are (1) improving the aesthetic, recreation, and fish and wildlife uses of stream corridors and their waters; and (2) increasing the awareness and appreciation of stream values by urban residents. Measures proposed to improve the awareness and appreciation of the public include beautifying the streams and increasing public access to them (Calif. Dept. of Water Res., 1981b).

Restoration of the streams in Berkeley should begin by addressing some problems which are contributing to the present deterioration of the stream environment. One problem is channel erosion resulting from abnormal scour of the streambank. There are several reasons for this abnormal scour. Channelization and other traditional flood control schemes are major factors because they dramatically alter the natural hydraulic properties of the stream. These traditional solutions seek to incrase the water flow capacity of the channel. The natural features of creeks, such as meandering and the presence of vegetation and other objects on the stream bed limit the carrying capacity of the waterway. Traditional flood control measures, therefore, removes these natural features and in the process change the dynamic flow equilibrium.

Storm drains are another cause of abnormal scour because they, too, alter streamflow. Storm drains increase both the total volume and velocity of water in the channel, as well as decreasing the lag time between rainfall and runoff

(Leopold, 1968). In addition, when impervious surfaces are constructed adjacent to streambanks, points of concentration are created, causing rill erosion of the bank. Pipes releasing runoff directly into channels also create points of concentration (Clark, 1974).

Recently proposed innovative flood control schemes can be applied to eliminate some of the causes of these erosion problems. Drains which filter runoff through soil rather than emptying it directly into the channel are one solution (Clark, 1974). Structural storm drainage systems can also be designed to maintain natural rates of flow by allowing for disposal of runoff into buffer areas of natural landscape. Soil and vegetation are remarkably efficient purifiers of polluted water (Clark, 1974). Detention of stormwater in basins or ponds is a third alternative. Water can be released at desired times to achieve a more uniform flow (Alley, 1974). Finally, bypass channels can be built to attenuate flows (Dawson, 1973).

Securing the stream bank is an important protective measure which reduces the destructive impact of abnormal flow. Along the edges of streams the natural root systems of plants are most effective in stabilizing the soil. There are several guidelines which should be followed when initiating streambank protection along East Bay creeks. The channels should be cleared of all unnatural obstacles. Protection should begin and end at stabilized points along the bank (U.S. Soil Cons. Service, 1974). Protection can employ either vegetative or structural means, or a combination of both. On areas subject to frequent inundation, structural means may be required. Vegetative means are suggested for areas subject to infrequent inundation. Reducing steep bank slopes will facilitate installation of protective measures. Undesirable plant species should be cleared, but only if the stability of the soil is not compromised (U.S. Soil Cons. Service, 1974).

Establishing vegetative bank protection is dependent upon the proper disposal of concentrations of water runoff. Methods discussed earlier may be used. Next, seeding or planting is required. Finally, the new vegetation must be protected until it becomes established (U.S. Soil Cons. Service, 1974). Native species, not exotics, should be planted. There are two problems associated with the use of exotics. First, they might out-compete and take over native plants. Second, wildlife have not adapted to using them as habitat. Besides stabilizing streambanks, revegetation is an important step in restoring natural beauty to the stream environment.

Stone riprap is probably the best structural means of bank protection. Riprap is an armor layer of rock or boulders placed on a site to prevent erosion. It does provide some wildlife habitat. Cement blocks should never be used. They are unsightly, provide a safety hazard, and do not offer wildlife habitat (Migel, 1974).

Fish and wildlife are important stream resources. The salmon and bass that used to swim in East Bay creeks are no longer a part of the local stream environment. But the streams are still important habitats. Codornices Creek is a significant home for the Pacific Tree Frog (Eimoto, 1982, pers. comm.). In 1977 it was reported that a few non-game species of fish could also be found in this creek (Albany Land Use Committee, 1977). Importing duff and rotting logs would improve wildlife habitat. Ponding of the streams would enhance the environment for amphibians and fish.

Once the natural creek environment has been stabilized, an important goal of creek restoration is to establish controlled public access. Appropriately placed walkways and vegetation are effective means of controlling pedestrian traffic along streams. In areas where the water is polluted, access should be provided along, but no to, the water.

Case Study: A Proposed Codornices Creek Park

Introduction

The California State Outdoor Recreation Plan recommends that a city provide a total of ten acres of park and recreation area (exclusive of school playgrounds) for each 1000 residents (City of Berkeley, 1977). At present, the city of Berkeley is far below meeting this standard, and to do so would require the acquisition of about 900 acres of open space (City of Berkeley, 1977). But like several other cities in the Bay Area, Berkeley considers this standard too high for already densely populated urban areas and has established its own goal of 2 acres of open space per 1000 residents, a goal which the city is close to meeting. It should be mentioned that these figures do not include open space provided by Tilden Park, an East Bay Regional Park located in the eastern foothills, and the University of California. Nevertheless, in terms of easily accessible neighborhood, open space there is a problem. The city is making an effort to acquire new parkland; recent additions include the Hearst Strip Park and a portion of the still-to-be-completed North Waterfront Park. But there are many neighborhoods which have no publicly owned recreational facilities other than school playgrounds (FIGURE 2). The areas

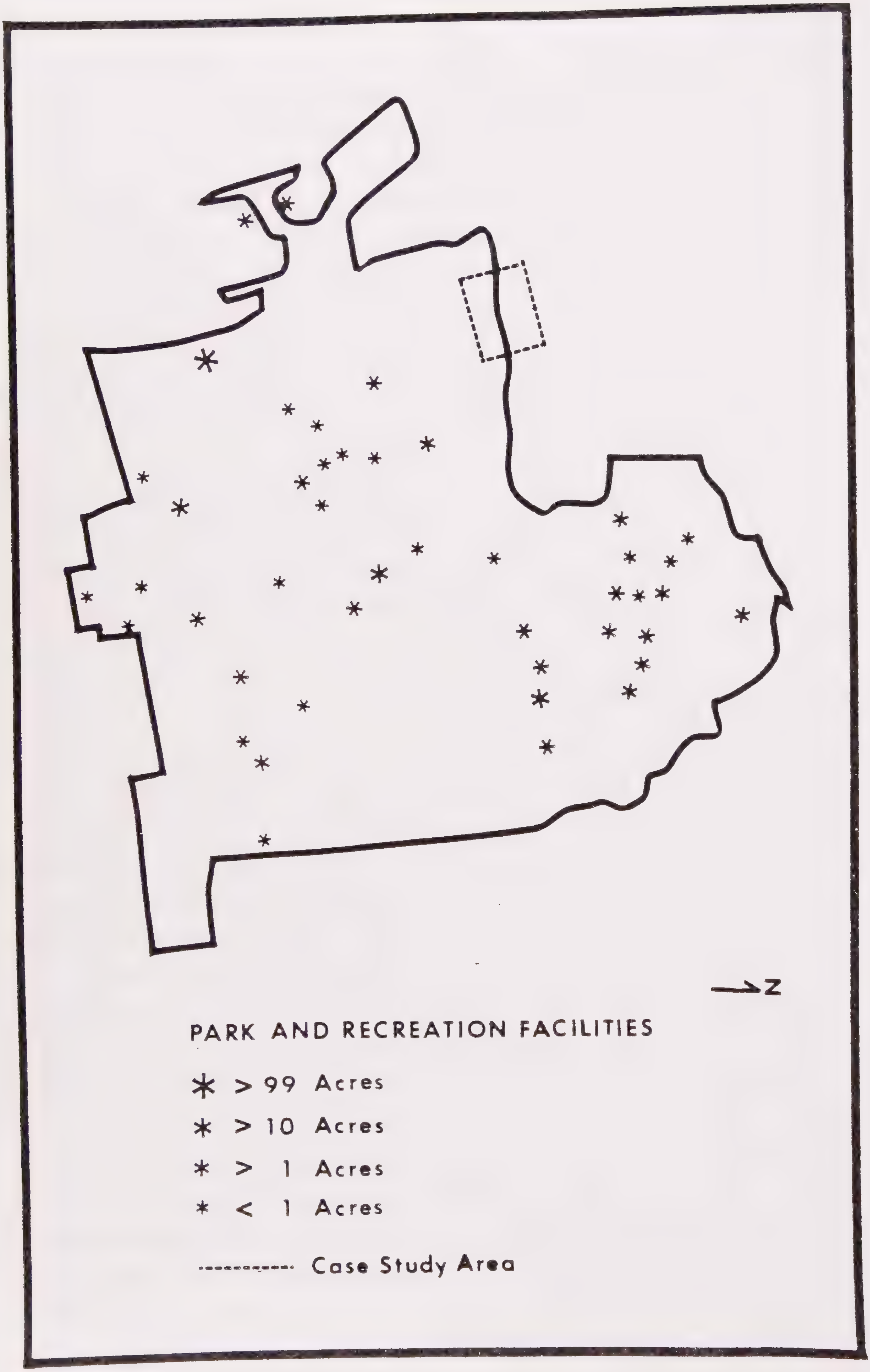

FIGURE 2. Berkeley Parks, Mini Parks and Totlots.
Source: Berkeley Master Plan, 1977.

of greatest need are in West and South Berkeley. Unfortunately, most of the approximately 250 acres of vacant land left in the city are located in the North Hills (City of Berkeley, 1977). The undeveloped land along the East Bay shoreline and the vacant sites surrounding Codornices Creek represent an important part of the remaining undeveloped land in West Berkeley. Although most of this land is not zoned residential, it is in close proximity to residential areas, and would serve well as accessible neighborhood open space. Both also represent important natural areas. I believe an East Bay Shoreline Park project should try to include as much of this open space as feasible. A non-contiguous parcel of land surrounding Codornices Creek near the shoreline is well suited for open space development (FIGURE 2).

Environmental Setting

Codornices Creek is a permanent stream; its north and south forks arise from springs in the Berkeley Hills (FIGURE 1). Codornices Creek is open most of its length as it flows along the border between Albany and Berkeley. It passes through predominantly residential neighborhoods as it winds down the foothills and through the eastern and central parts of the bay plain (Albany Land Use Committee, 1977). As this tream emerges after passing under San Pablo Avenue it flows above ground for several blocks except where it is bridged under cross streets and part of a vacant industrial lot. This reach of Codornices Creek has been studied for park potential.

University Village, a University of California-owned married student apartment complex, occupies the property adjacent to the north bank of this section of Codornices Creek. Privately-owned lots zoned for manufacturing occur in Berkeley adjacent to the south bank. Parts of the property on both sides of the stream have been left undeveloped; however, there are some buildings adjacent to the channel. Cyclone fencing surrounds much of the creek.

The natural stream environment of Codornices Creek is weak along this reach. Several points along the stream bank are experiencing erosion. After a recent spring rain (1982), a few small bushes and mounds of soil were observed on the bottom of the channel impeding water flow. A few sections of the steeply sloped bank have been secured with sandbags and cement. One large chunk of cement has been placed in the channel at the Ninth Street crossing, presumably to deflect water from the southern bank. There is industrial and automobile pollution in the area, as well as noise from these sources and trains which pass on the railroad tracks nearby.

The area is in need of landscaping. Most of the riparian vegetation is gone. There are very few trees left; in most places grasses have taken over (Albany Land Use Committee, 1977). Birds use the creek as a resting place and watering hole along their migratory paths.

There are a large number of people living nearby this study area, particularly to the east and north. This population is ethnically diverse. Groups with significant representation include, blacks, Japanese, Chinese, Filipinos, and whites. Both renters and homeowners are found in large numbers. Residents of University Village constitute a large fraction of the renters.

Recommendations

A park at this location would provide open space for a neighborhood that needs recreational resources. The shortage of accessible neighborhood open space described earlier in Berkeley is also found in Albany. Because the University of California, which owns most of the land along the north bank of the creek, has tax-exempt status no property taxes are paid on this land. Hence, the University should share with the cities of Albany and Berkeley the cost of developing this open space.

The site has great potential for park development. The presence of a few buildings adjacent to the channel along this reach precludes the establishment of one large single park. However, smaller parks could be developed at several locations. Improvements which would not displace existing land use could also be made to increase available space. For example, two streets which are presently blocked off with fences, Ninth and Seventh Streets, could be permanently divided, and the roadways over the creek removed. A small grass field exists on the University Village property adjacent to the channel between Eighth and Ninth Streets. The fence separating the stream and the field could be removed and the bank given a more gradual slope. Riparian vegetation could be replanted and the stream environment reestablished. Creating ponded areas would surely attract more fish and shorebirds. Dechannelizing the creek in this manner would require reducing the inflow or runoff and slowing the flow of water in the channel. This could be done using one or more of the innovative flood control schemes mentioned earlier. A park such as this would make an indeal connector link between San Pablo Avenue and the East Bay shoreline.

Conclusion

It is hoped that the future will bring increased awareness on the part of residential, commercial and industrial interests as well as government agencies of the importance of preserving urban streams throughout the East Bay. Creeks represent the most important natural areas left within the cities. In addition to preserving open space, stream restoration would have many beneficial impacts on the surrounding environment. A restoration program to repair and revegetate the remmants of natural creek left in Berkeley is needed today. The support of all the groups mentioned above is needed to produce truly effective results. Acquisition and development as open space of the stretch of Codornices Creek near the bay in conjunction with an East Bay Shoreline Park project is a perfect opportunity to initiate such a program.

REFERENCES CITED

Albany Land Use Committee, Creek Restoration Program, approved by the Albany City Council on December 5, 1977, 11 p.

Alley, William, 1974. Effects of Stormwater Detention in Urban Areas: Boulder, CO, Western Interstate Commission for Higher Education, 58 pp.

California Department of Water Resources, October, 1980. Alameda Creek Urban Streams Study, Progress Report: Red Bluff, CA, Department of Water Resources, 82 pp.

__________, 1981a. Urban Streams Study: Linda and Cirby Creeks, Placer and Sacramento Counties: Sacramento, CA, 56 pp.

__________, 1981b. Request for proposals for Urban Streams Cleanup and Restoration Program: Sacramento, CA, 29 pp.

City of Berkeley, CA, 1977. Berkeley Master Plan, 204 pp.

Clark, John, 1974. Coastal Ecosystems: Ecological Considerations for Management of the Coastal Zone: Washington, D.C., Conservation Foundation, 178 pp.

Dawson, Kerry Joel, 1973. Natural Symbols as a Basis for the Use and Design of Urban Natural Environments: A Cast Study of San Ramon Creek, unpub. M.L.A. thesis, University of California, Berkeley, 195 pp.

Dearinger, John A., 1968. Esthetic and Recreational Potential of Small Naturalistic Streams near Urban Areas: Lexington, Kentucky, University of Kentucky Water Resources Institute, 260 pp.

Eimoto, Dennis, Assistant Fisheries Biologist, California Department of Fish and Game, pers. comm., April, 1982.

Leopole, Luna, 1968. Hydrology for Urban Land Planning: A Guidebook on the Hydrologic Effects of Urban Land Use. U.S. Geological Survey Circular 554: Washington, D.C., 18 pp.

Migel, J. Michael, 1974. The Stream Conservation Handbook: New York, Crown Publishers, Inc., 242 pp.

Pimentel, David, and Marcia Pimentel, 1979. Food, Energy and Society: London, Edward Arnold, 165 pp.

REFERENCES CITED

(continued)

Shipounoff, Dimitri, November, 1979. Trout Fishing in the Berkeley Hills: Berkeley Monthly, v. 10. no. 2, pp. 11-13.

Tri-Cities Citizens Advisory Committee, 1973. Open Space and Conservation Elements of the General Plan: A Report to the Cities of El Cerrito, Richmond and San Pablo, 98 pp.

U.S. Department of Commerce, Bureau of the Census, 1982. Census Area Profiles, City of Berkeley: Berkeley, CA, ABAG Regional Data Center.

U.S. Department of Housing and Urban Development, Federal Insurance Administration, 1976. Flood Insurance Study, City of Berkeley, Alameda County, CA.

U.S. Soil Conservation Service, 1974. Erosion and Sediment Control Handbook for Urban Areas, West Virginia: Morgantown, West Virginia, United States Soil Conservation Service, 156 pp.

Wolfe, Doug, Landscape Architect, Parks Design Department, City of Berkeley, pers. comm., March, 1982.

Chapter 7

THE SOUTH RICHMOND MARSHES: AN ECOLOGICAL ANALYSIS

Mark Oddi

Introduction

Along the south Richmond shoreline immediately north of Pt. Isabel and extending towards Richmond's Inner Harbor Basin, a serene salt marsh community exists (FIGURE 1). Hardly noticed by motorists on Hoffman Boulevard just east of the marsh, it manages to survive amid chemical and heavy industries, rail-served industrial parks, and flagrant acts of vandalism.

Wildlife is abundant; migratory and resident birds are the most obvious marsh users, but small mammals are also well represented. Stands of cord grass and pickleweed, the floral bulwarks of a salt marsh community, form the base of a food chain

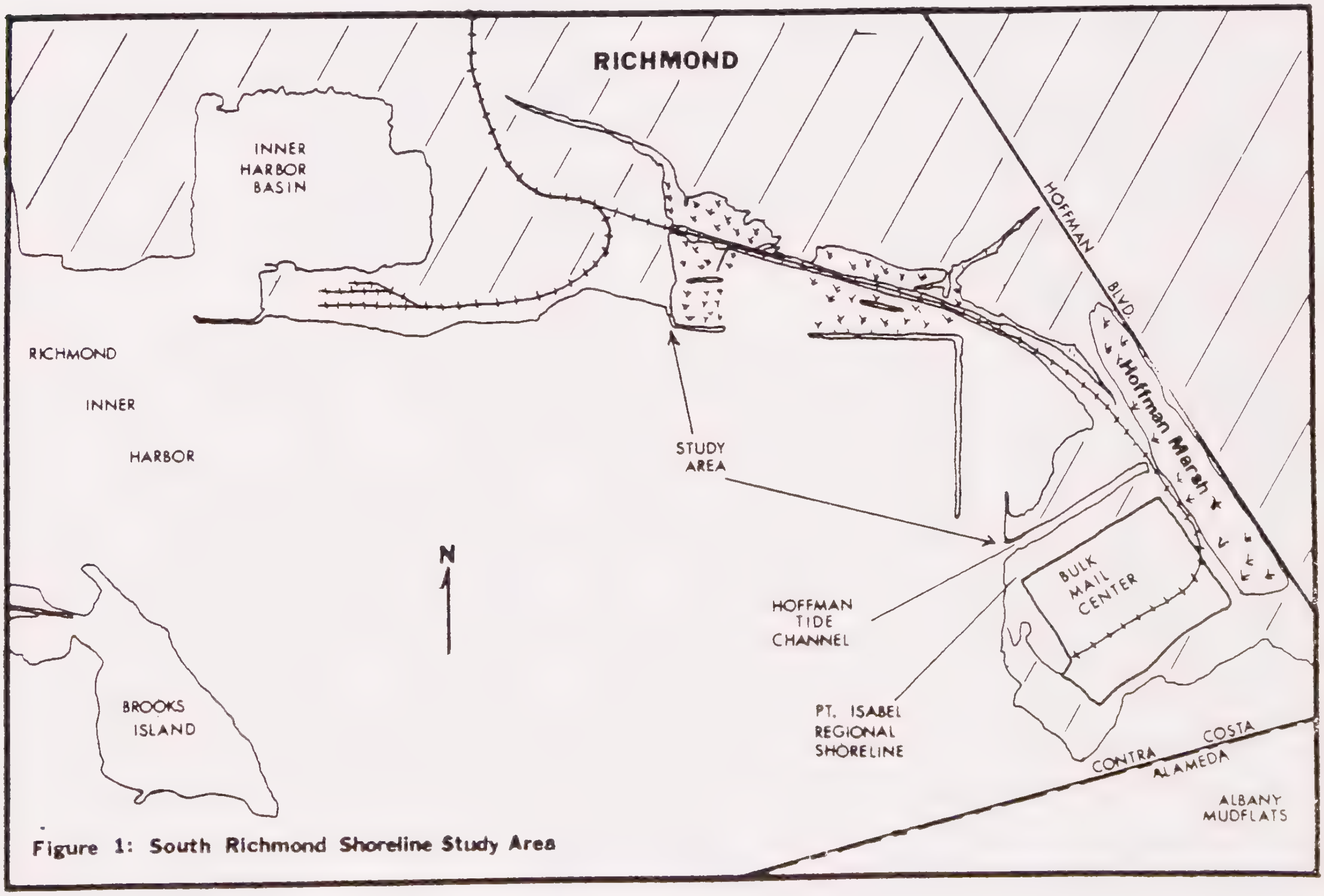

Figure 1: South Richmond Shoreline Study Area

upon which the diverse fauna have come to rely.

Extending south of Pt. Isabel and reaching to the Bay Bridge Toll Plaza, the East Bay shoreline exhibits partially developed, peninsular landfills with intermittent salt marshes and mudflats. The California Coastal Conservancy was chosen to provide guidance in implementing various park proposals for the remainder of the undeveloped landfill along the shoreline. For various political and economic reasons the Conservancy chose as its northern jurisdictional limit the Hoffman tide channel (FIGURE 1), including the Hoffman Marsh (Peter Brand, 1982, pers. comm.). The wetlands north of this boundary come under the policies of the South Richmond Shoreline Special Area Plan (South Richmond Shoreline, 1977).

The entire East Bay shoreline, however, encompasses a dynamic biotic community which does not recognize political or otherwise temporal delineations of its habitat. It is important to realize that development in one area can impact wildlife along the entire shoreline, due to the mobility of birds and certain other animals.

I feel that the various agencies involved in the two areas, namely those guided by the Coastal Conservancy and those guided by the South Richmond Special Area Plan, should work together in their decision-making processes. Because land use policies have already been adopted for the South Richmond Shoreline Area, development there could serve as a model for the remaining East Bay shoreline. I will attempt to foster a concerted effort by presenting a synopsis of environmental policies regarding the South Richmond Area, and I will present my own ecological analysis.

Site Description

The approximate geographic limits of my study area are shown in FIGURE 1. FIGURE 2 presents the specific area upon which I have based my ecological analysis. The following paragraph describes the area shown in FIGURE 2.

Upon crossing the railroad bridgethat spans the Hoffman tide channel, one encounters the 45 acre Santa Fe Land, Inc. property (formerly Santa Fe Land Improvement Co.), bayward of the railroad track. I have designated this area as Zone 1. One half of this property is vacant landfill; the other half is tidal mudflat. Farther north, the landfill narrows to become a railroad levee which separates two distinct marsh areas. The bayward marsh (designated Zone 2) of approximately 50 acres, is characterized by a mix of salt marsh plants (predominately cordgrass and pickleweed) and integrated mudflats. Three-quarters of this marsh is enclosed by a stone breakwater that is popular with both birds and fishermen. The marsh shoreward of the railroad levee (designated Zone 3) encompasses approximately 40 acres.

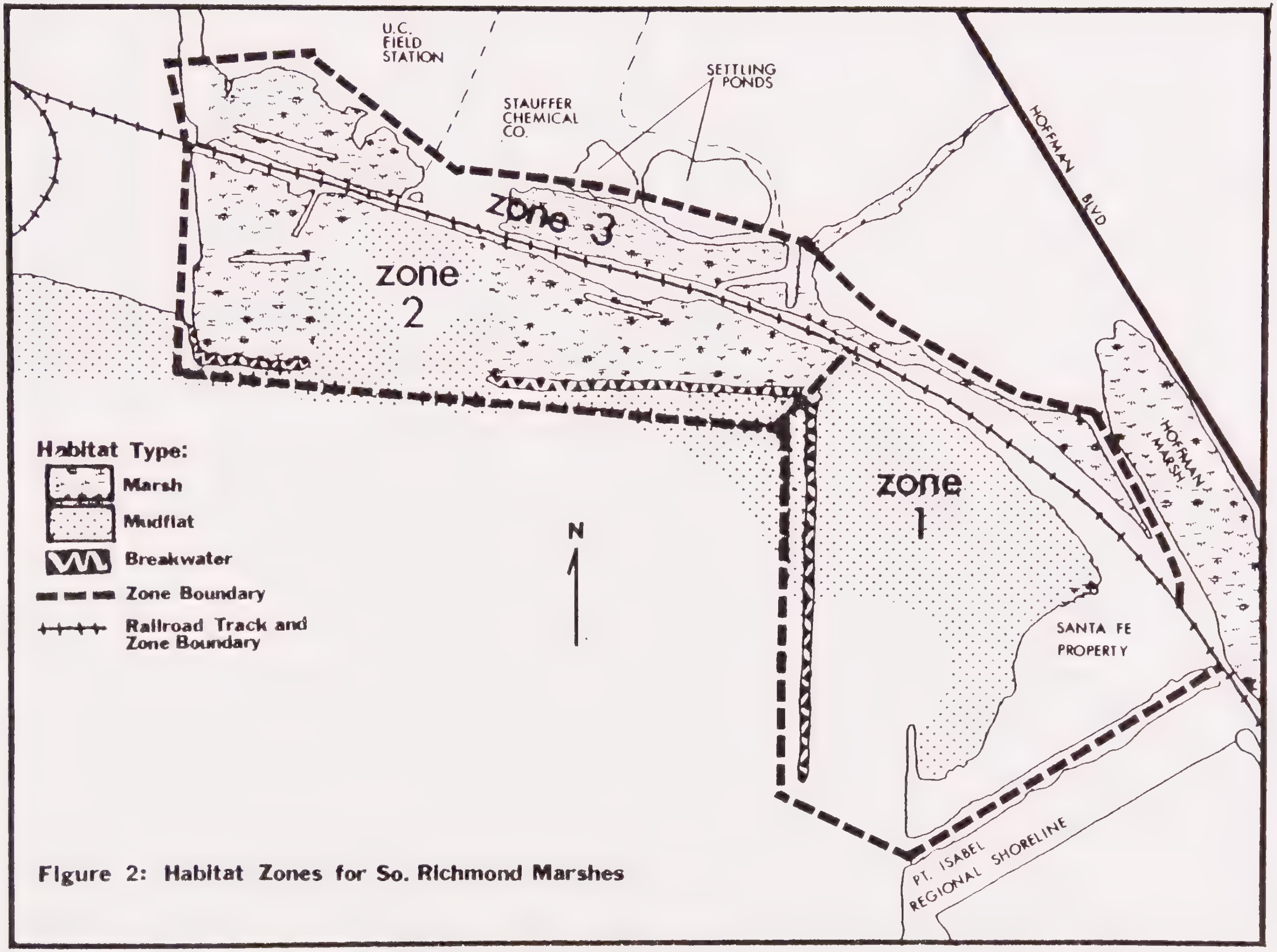

FIGURE 2. Habitat Zones of the South Richmond Marshes.

Source: South Richmond Shoreline Special Area Plan, 1977.

There are actually two distinct marshes here, each draining into the bayward marsh through a separate breach in the levee. They are of poorer quality than the bayward marsh because of their removal from direct tidal action by the levee. The upland area immediately surrounding the marshes is a mix of grassy vacant lots, and both heavy and light industry.

Previous Studies

In the past, landfill could be placed in San Francisco Bay wherever it made economic sense. The pristine tideland ecosystem which had existed along the South Richmond shoreline was obliterated by landfill, and what remained was partitioned by railroad levees and breakwaters. Landfill operations began in the early 1900's and continued until 1969. The primary constituents of the fill are clay, sand and compacted silt. Seismic events could induce ground failure (e.g., liquefaction and subsidence), a hazard common to man-made landfills overlying bay mud (BCDC, 1977).

The earliest environmental analysis is provided by the U.S. Army Corps of Engineers which prepared an Environmental Impact Statement in June of 1973 for the construction of the U.S. Bulk Mail Center (FIGURE 1). It was determined that because all construction would occur on relatively recent landfill, no adverse environmental impacts would be incurred. The 20 acre Pt. Isabel Regional Shoreline (FIGURE 1) was created to provide public access and enjoyment of the shoreline as mitigation for development.

Three months later, the California Department of Transportation published the first authoritative analysis of the Hoffman marsh and Albany mudflat (URS Research, 1973). It reviewed possible impacts of various alternatives Caltrans was proposing for the widening of Highways 17 and 80.

The report notes that the Hoffman marsh and Albany mudflat form the only existing stand of marsh vegetation in a five mile length of East Bay shoreline (URS, 1973). In addition, most marsh destruction in San Francisco Bay has been in the central and south bays, where the effects of urbanization have been greatest. The largest proportion of marshland that remains in the bay is in the more rural north bay and Delta regions. These northern marshes are characterized by fresh and brackish waters which support a plant and animal life distinct from the more saline south and central bay marshes. Therefore, because of the area and habitat-type imbalance, the marshes in the south and central bays become biologically very important because so little of them remains (URS, 1973). This is a critical point to consider in any instance involving mitigation on an acre-for-acre basis.

The URS study also found that species diversity and biomass of benthic invertebrates are higher near the borders of mudflats than areas farther from shore (URS, 1973). This could have implications for shorebird health and welfare if visitor use of the shoreline became heavy.

In 1980, Caltrans completed its own EIS (Caltrans, 1980) for the widening of Highway 17. In the marsh vicinity, a proposal now termed "D_1 modified," has been adopted. This proposal will claim 1.3 acres of wetland, of which 0.8 acres is low-grade residual marsh (Caltrans, 1980). Planned mitigation calls for the rejuvenation of 7.5 acres of the southern Hoffman marsh. A levee now isolating this portion of the marsh would be breached to provide better tidal circulation. Appropriate landscaping along the highway is also planned, utilizing native shrubs and trees (Caltrans, 1980). There may be no impacts on high quality marshes in the area if a new I-180/80 interchange site north of Central Avenue is found (Caltrans, 1980). Other mitigation measures under consideration include dredging of the existing marsh network to improve tidal circulation and breaching of railroad levees to create islands which would provide secure nesting sites for marsh wildlife (Caltrans, 1980, p. 138, Plate 39-2).

Although the Hoffman marsh is within the range of four endangered species, the report concluded that no deleterious effects would occur by implementation of the D_1 modified proposal. If all mitigation measures are adopted, overall habitat quality would probably be improved (Caltrans, 1980).

The San Francisco Bay Conservation and Development Commission (BCDC) acted as lead agency in drafting a final environmental impact report in conjunction with the Special Area Plan for the South Richmond Shoreline; both were adopted in 1977. The EIR resolved conflicts between the Richmond General Plan and the BCDC Bay Plan. The Special Area Plan recognizes that the marshes and tidelands provide significant wildlife habitat for many species of animals, particularly birds. In addition, Brooks Island (FIGURE 1) provides a valuable habitat for native flora. Upland areas are zoned industrial: the University of California Field Station, Stauffer Chemical Company and the U.S. Bulk Mail Center are the primary users (BCDC EIR, 1977).

The BCDC EIR indicates that storm drainage presents a particularly hazardous problem. The shoreline waters of South Richmond contain pollutants such as heavy metals (e.g., lead and mercury), corrosives, chemicals, oil, and other petroleum products. The discharge problem has been compounded by the deteriorating and abandoned drains within the shoreline area (BCDC EIR, 1977).

Land use policies adopted in the Special Area Plan include: (1) the protection of marshes, mudflats, tidelands and open water to the maximum extent feasible, (2) encouragement of public access along the bay shoreline during the course of future development, and (3) retention of the existing Santa Fe landfill (FIGURE 2) as a preservation area (open space recreation, limited access) until the proper permits are issued for development (South Richmond Shoreline, 1977).

The Santa Fe Plan

Santa Fe originated the fill project before the Bay Plan was adopted and is exempt (due to a grandfather clause) from the need to obtain BCDC approval; but only if the project remains the same and is completed "in a timely manner" (BCDC EIR, 1977). Twenty acres of the 45 acre tideland property had been filled by 1969 when filling operations terminated.

An application to resume filling of the remaining 25 acres of tideland was submitted to the U.S. Army Corps of Engineers in February of 1977. Six hundred thousand cubic yards of imported material would have been used as fill to create a rail-served industrial park (Santa Fe permit applications).

Public response to this proposal was considerable. The Resources Agency of California noted that as of 1977, the mudflats surrounding the proposed fill area contained a minimum of 30,000 Japanese littleneck clams and a minimum of 20,000 softshell clams. The softer mudflats offshore also contained high populations of marine worms and small clams. Adult striped bass, starry flounder, and other sport fishes frequent this area to feed on juvenile fishes, bay shrimp and other marine organisms. Fishing success in the area is subsequently high (Goodson, 1977).

The California Department of Fish and Game, the U.S. Fish and Wildlife Service, and others opposed the fill for its potential destruction of wildlife habitat. The State Lands Division also stated that the proposed project occupies sold unreclaimed lots, and a serious doubt remained concerning the ownership of the lands by Santa Fe (Goodson, 1977).

The request for a permit was denied by the Corps on December 1, 1977. Their findings stated that the total public interest would not be served by the implementation of this project (Adsit, 1977). It is unknown at this time what future plans Santa Fe has concerning this property.

Methods

In making my own analysis of the South Richmond Shoreline (FIGURE 2), I selected several days at random each week to observe and census wildlife. Lists are compiled

for both plants and animals from a total of 14 days observation which began 3/12/82 and ended 4/25/82. I spent an additional 6 days during the month of May collecting plant specimens as they came into flower.

I divided the site into 3 zones as outlined in FIGURE 2 and as described previously under site description. The birds are classified according to habitat, seasonality and maximum abundance during the census period. The other animals are classified only as to occurrence. The flora are grouped into indigenous marsh species and those species particular to landfill or upland areas. All floral identifications are based on Munz and Keck (1968).

Stephen F. Bailey of the Museum of Vertebrate Zoology provided invaluable assistance in annotating the bird list. The staff of the Jepson Herbarium also gave helpful assistance with plant specimens.

Results

Only the most prominent fauna and flora will be discussed, but TABLES 1 and 2 give a complete list of the birds and flowering plants, respectively.

Zone 1

The 20 acre Santa Fe landfill, despite its recent origin, supports a rich mixture of native and exotic shrubs, ornamentals and weeds. The shoreline is too precipitous for most salt marsk plants, although one area, approximately 200 square meters in extent, supports a miniature salt marsh community (FIGURE 2).

Pickleweed, *Salicornia virginica*, dominates the lower tidal zones with salt grass, *Distichlus spicata* var. *stolonifera*, occupying the higher peripheral margins. Growing throughout are sea lavender, *Limonium californicum*, jaumea, *Jaumea carnosa*, brass buttons, *Cotula cornopiflora*, and fat hen, *Atriplex* spp. The marsh appears to be expanding out onto the mudflat. Gumplant, *Grindelia humilis*, typically found in the transitional zone between salt marsh and upland, is quite abundant along the shoreline and occurs sporadically inland. Small growths of pickleweed and salt grass are also found scattered along the shore.

The most striking vegetational feature of the upland is the dark green coyote bush, *Baccharis pilularis consanguinea*, that rises up to 2.5 meters above the rumpled landscape. A few large specimens of the native arroyo willow, *Salix lasiolepsis*, grow at the southwest corner of the landfill. The broom, *Cytisus canariensis*, grows interspersed between the ubiquitous coyote bush. These individuals are generally found along the shoreline and parallel to the railroad track.

Species[+]	A[1]		B	C
Common Loon	2	(3-20)	W	W
Horned Grebe	1	(4-3)	W	W
(Eared Grebe)	-		W	W
Western Grebe	3	(4-14)	W	W
Pied-billed Grebe	2	(3-19)	W	W
(Brown Pelican)	-		S	W,B
Double-crested Cormorant	1	(3-28)	R	W,B
Brandt's Cormorant	1	(4-25)	W	W
Great Blue Heron	1	(3-17)	R	S,M,U
Great Egret	6	(3-21)	R	S,M,U
Snowy Egret	11	(3-17)	R	S,M,U
Black-crowned Night Heron	1	(4-25)	R	S,M,U
Mallard	12	(4-25)	R	S
Pintail	5	(3-21)	W	W
Canvasback	12	(3-19)	W	W
Greater Scaup	70*	(4-14)	W	W
Lesser Scaup				
Bufflehead	2	(4-1)	W	W
Common Goldeneye	2	(3-17)	W	W
Surf Scoter	20	(3-19)	W	W
White-winged Scoter	1	(3-20)	W	W
Black Turnstone	3	(3-14)	W	M
Ruddy Duck	40	(3-19)	W	W
White-tailed Kite	2	(4-3)	R?	U,S
Red-tailed Hawk	2	(4-7)	R	U
Marsh Hawk	2	(3-19)	W?	S,U
American Kestrel	1	(4-7)	R?	U
American Coot	25	(3-20)	W or R	W,M,S
American Avocet	14	(3-17)	W or R	M
Semipalmated Plover			W	M,B
Killdeer	≈700*	(4-14)	R	M,U,B
Black-bellied Plover			W	M,B
Marbled Godwit	8	(3-19)	W	S,M
Whimbrel	6	(4-25)	M or W	S,M
Long-billed Curlew	8	(3-20)	W	S,M
(Greater Yellowlegs)	-		W or M	S,M
Willet	200	(3-19)	W	S,M
Short-billed Dowitcher	43	(4-14)	W	M
(Long-billed Dowitcher)	-		W	M,S
(Red Knot)	-		W	M
(Sanderling)	-		W	M
(Western Sandpiper)	-		W	M
(Least Sandpiper)	-		W	M
Dunlin	67	(3-19)	W	M
(Glaucous-winged Gull)			W	M,B
Western Gull			R	M,B
Herring Gull			W	M,B
(Thayer's Gull)			W	M,B
California Gull	≈ 200*	(4-14)	W or R	M,B
Ring-billed Gull			W	M,B,W
(Mew Gull)			W	M,B,W
(Bonaparte's Gull)			W or M	M,B,W
Forster's Tern	31	(3-21)	R	W,M
Caspian Tern	7	(4-25)	S	W,M
Rock Dove	3	(3-21)	R	U
Mourning Dove	18	(4-7)	R	U
(Barn Owl)	-		R	U
(Great Horned Owl)	-		R	U
(Burrowing Owl)	-		R	U
(Short-eared Owl)	-		W	U
White-throated Swift	1	(3-28)	S	U,S
Anna's Hummingbird	1	(4-3)	R	U
Belted Kingfisher	1	(3-19)	W or R?	W
Common Flicker	2	(3-20)	R or W	U
(Say's Phoebe)	-		W	U
Barn Swallow	12	(4-25)	S	S,U
(Cliff Swallow)	-		S	U
Common Crow	8	(3-20)	R	U,M
Bushtit	14	(3-28)	R	U
Northern Mockingbird	2	(3-21)	R	U
(Water Pipit)	-		M or R	U,S
Yellow-rumped Warbler	1	(3-20)	W	U
Starling	5	(3-28)	R	U,S
Western Meadowlark	3	(3-17)	R?	U
Red-winged Blackbird	31	(4-25)	R	U,S
Brewer's Blackbird	7	(4-3)	R	U
House Finch	20	(4-3)	R	U
American Goldfinch	12	(4-3)	S or R	U
(Savannah Sparrow)	-		W	U
White-crowned Sparrow	9	(3-19)	W	U
Song Sparrow	30	(4-1)	R	U,S
Brown-headed Cowbird	1	(4-25)	R	U

[1] Notes:
Column A-Maximum Daily Count and Date.
Column B-Occurrence during year; W=winter, S=summer, M=migrant only, R=resident.
Column C-Habitat where sp. is typically found; W=water(swimming), B=breakwater, S=marsh, M=mudflat(standing), U=upland

+This is a complete list of species observed, plus a select group of species in parentheses that were not observed, but are expected to occur here. Annotated by Stephen F. Bailey.

*Scaups, Plovers, and Gulls are grouped here because specific identification in winter plumage requires expert knowledge.

Table 1. Birds of the South Richmond Marshes.

Species+	Common Name	Zones in Which it Was Found
**Spartina foliosa*	Cord grass	2,3
**Salicornia virginica*	Pickleweed	1,2,3
**Salicornia subterminalis*	Pickleweed	2,3
**Distichlis spicata* var. *stolonifera*	Salt grass	1,2,3
**Limonium californicum*	Sea lavender	1,2,3
**Grindelia humilis*	Gum plant	1,2,3
**Jaumea carnosa*	Jaumea	1,2,3
**Cotula cornopifolia*	Brass buttons	1,2,3
**Atriplex* sp.	Fat hen	1,2,3
**Frankenia grandifolia*		2
**Cuscuta salina*	Dodder	1,2,3
**Spergularia macrotheca*	Sand spurrey	1,2
**Spergularia marina*	Sand spurrey	1,2
**Triglochin concinna*	Arrow grass	1,2,3
**Parapholis incurva*	Sickle grass	1,2
Scrophularia californica	Figwort	1,2,3
Rumex crispus	Curly dock	1,2,3
Rumex occidentalis	Western dock	1,2,3
Foeniculum vulgare	Sweet fennel	1,2,3
Kentranthus ruber	Red valerian	1,3
Dipsacus sativus	Fullers teasel	3
Brassica nigra	Black mustard	1,2,3
Brassica campestris	Field mustard	1,2,3
Raphanus sativa	Wild radish	1,2,3
Lobularia maritima	Sweet alyssum	1
Plantago lanceolata	English plantain	1,2,3
Lupinus arboreus	Lupine	2,3
Lupinus bicolor ssp. *pipersmithii*	Lupine	1
Lupinus succulentus	Lupine	1
Vicia sativa	Spring vetch	1,3
Medicago polymorpha	Bur clover	1,2,3
Lathyrus latifolius	Everlasting pea	1
Acacia decurrens	Acacia	1
Cytisus canariensis	Broom	1,3
Convolvulus arvensis	Bindweed	3
Sisyrinchium arvensis	Blue-eyed grass	3
Avena fatua	Wild oat	1,2,3
Bromus rubens	Foxtail chess	1,2,3
Phalaris aquatica	Harding grass	3
Geranium dissectum	Cranesbill	1,3
Ambrosia chamissonis	Ragweed	1,2,3
Baccharis pilularis ssp. *consanguinea*	Coyote bush	1,2,3
Cirsium vulgare	Bull thistle	1,2,3
Picris echioides	Ox tongue	1,2,3
Senecio vulgaris	Common groundsel	1,2,3
Silybum marianum	Milk thistle	1,2,3
Sonchus oleraceus	Sow thistle	1,2,3
Anagallis arvensis	Scarlet pimpernel	1
Phacelia californica		3
Malva nicaeensis	Mallow	1
Eschscholzia californica	California poppy	1,2,3
Mesembryanthemum chilense	Sea-fig	1,2,3
Mesembryanthemum edule	Hottentot-fig	1,2,3
Salix lasiolepsis	Arroyo willow	1,3

+Due to time limitations this list neglects many species but represents those species that best characterize the South Richmond marshes.
*Indicates species is typically associated with salt marsh communities.

Table 2. Flowering Plants of the South Richmond Marshes.

Shorebirds are infrequently found here. Egrets, willets, and killdeers are casual visitors. Mallard, bufflehead, and common goldeneye also occasionally visit the two main tide channels. The belted kingfisher is the only water bird I found in Zone 3 that did not occur elsewhere. It hunts for fish by hovering above the tide channels, swiftly diving into the water when prey is sighted.

Upland bird species are relatively abundant. The presence of several species of raptors distinguishes this area from all other marshes along the East Bay shoreline. The red-tailed hawk, marsh hawk, white-tailed kite and American kestrel frequently patrolled the grassy uplands. A large stand of mature eucalyptus trees on the University property adjacent to the marsh is the current roost for all of these birds. The marsh hawk is the most frequent visitor to the salt marsh; the other predatory birds hunt predominately on the surrounding upland areas, although I did observe the kite make one kill among the pickleweed. Other upland bird species that are common here include the common crow, red-winged blackbird and barn swallow.

Zone 3 contains all mammals that were reported for Zones 1 and 2. In addition, I believe the endangered Salt Marsh Harvest Mouse (SMHM) could exist in the marsh adjacent to the University Field Station. I discovered several mice nests among the shoreline debris and one mouse was sighted but not confirmed as a SMHM. A central, narrow island could offer refuge for these mice from excessive high tides. Dave Olsen's paper considers the SMHM in greater detail.

Discussion

Life in the South Richmond Marsh, like that in all other marshes around San Francisco Bay, revolves around the semi-diurnal tides, with shorebirds generally feeding on the ebb tide. As the tide begins tis ebb flow, bird species sequentially replace one another as different benthic prey species become available (Stephen F. Bailey, 1982, pers. comm.). The number of bird species feeding on a given mudflat at a given time belies the actual number of species that use the mudflat in question. Because species will feed at different times in relation to one another and in specific locales depending on their morphological adaptations, competition is reduced (Stephen F. Bailey, 1982, pers. comm.).

A notable feature of these marshes is the variety of habitat available. Birds frequently fly from one area to another to exploit the varying food resources as they are uncovered by the tides. For example, during the stages of high tide, willets would feed among the thick growth of pickleweed in the Hoffman Marsh. As

the tide receded, groups of willets would proceed to the outboard marshes and feed along the cordgrass/mudflat edge which had been previously flooded.

The benefit to shorebirds of having a variety of habitats available, in this case several distinct mudflats and marshes, is that prey populations can be locally high in one area and shorebirds can concentrate feeding there. Prey diversity composition may also vary among habitats and support a more diverse bird population. The important point here is that wildlife populations can best be served by maintaining as many diverse habitats as possible.

Hazards to the Marsh

There are several present and future areas of concern regarding the marshes in South Richmond. Presently, illegal debris dumping occurs quire regularly. Besides offending one's sense of sight and smell, it destroys marsh flora. Vehicles have access to the Santa Fe landfill via the railroad bridge that spans the Hoffman Marsh tide channel. Trucks, and especially motorcycles, frighten wildlife and damage vegetation. There are no signs posted barring vehicles from access. This tends to imply that access is permitted by default.

Shooters with .22 caliber rifles, air rifles, and bows and arrows also frequent the marshes. On one particular day I had to duck down to avoid rifle bullets whistling over my head. This is an obvious threat to public safety, not to mention the animals that are caught in a hunter's sights. The Richmond municipal code bans all shooting and the hunting of wildlife in this area, but enforcement of the law is minimal due to the isolated nature of the marshes.

Future concerns include an increase of public usage. I estimate that 10 people per day visited the marshes during my observation period. On several occasions no one was sighted. The City of Richmond has plans for changing this sparse visitor use by allowing construction of high density residential units adjacent to the northwest border of the marsh (Marshal Walker, 1982, pers. comm.). Plans call for an interpretive center and the possible removal of the railroad track to allow for a pedestrian trial to be built upon the levee, with the marsh becoming a park. In addition, the Richmond Special Area Plan states that the large, 90 degree breakwater (FIGURE 2) offers good potential for a public fishing site (South Richmond Shoreline, 1977). This breakwater is now accessible to humans only at low tide, and then only with difficulty because of the soft mud. The interpretive center and pathway are a positive step toward park development, but I feel that public fishing should be confined to the smaller, western breakwater. Since large

numbers of wintering shorebirds use the larger breakwater for resting, human access should not be allowed.

Conclusion

In terms of shorebird use, the South Richmond marshes are surpassed only by the Emeryville Crescent and Albany Mudflat along the East Bay shoreline. In terms of salt marsh acreage, only the Emeryville Crescent is superior. For these reasons alone, the South Richmond marshes must figure prominently in an integrated East Bay Shoreline Park plan.

All things considered, the South Richmond marshes are on fairly stable ground, ecologically speaking. The Special Area Plan recognizes the area's potential for park development and the East Bay Regional Park District would provide the means for doing so. Brooks Island already enjoys the protection afforded by the Park District but has not yet been opened to the public.

Under the Park District's management, vehicles would not longer have access, thus preventing debris dumping, off-road vehicles and motorcycles. The presence of park personnel and information centers would benefit the public and effectively discourage hunters from harassing wildlife (Nelson, 1982, pers. comm.).

I would like to close and sum up my feelings about "development" in general by quoting from the late ecologist, Aldo Leopold. In his book, A Sand County Almanac, Leopold writes, "A thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong when it tends otherwise" (Leopold, 1949, p. 224).

REFERENCES CITED

Adsit, John M., Dec. 1, 1977. U.S. Army Corps of Engineers, San Francisco District, Findings of Fact concerning proposed fill by Santa Fe Land Improvement Co. (#11585-47).

Bailey, Stephen F., Senior Ornithologist, Golden Gate Audubon Society; Museum of Vertebrate Zoology, pers. comm., 1982.

California Department of Transportation, 1980. Final Environmental Impact Statement, Hoffman Corridor, Volume 1: San Francisco, California, 204 pp.

Goodson, L. Frank, Aug. 10, 1977. Letter from the Resources Agency of California to the Army Corps of Engineers, San Francisco District, concerning Public Notice No. 11585-47.

Leopold, Aldo, 1949. A Sand County Almanac: New York, Oxford University Press, 226 pp.

Martin, Alexander C., 1972. Weeds: New York, Golden Press, 160 pp.

REFERENCES CITED

(continued)

Munz, P.A., and D.D. Keck, 1959. A California Flora: Berkeley, California, University of California Press, 1681 pp.

Nelson, Christian, Chief of Parks and Information, East Bay Regional Park District, pers. comm., 1982.

Paul, W.L., Feb. 28, 1977. Santa Fe Land Improvement Co.'s fill permit application to the Army Corps of Engineers, San Francisco District, number 11585-47.

San Francisco Bay Conservation and Development Commission and the City of Richmond, 1977. Final Environmental Impact Report on the Special Area Plan for the South Richmond Marshes: Richmond, California, 108 pp.

South Richmond Shoreline Special Area Plan Citizens Advisory Committee, 1977. South Richmond Shoreline Special Area Plan: Richmond, California, 114 pp.

URS Research Co., 1973. Marine Environmental Impact Analysis, Widening Highways 17 and 80 Along Shoreline of Richmond, California: California Department of Transportation, 150 pp.

Walker, Marshal, Urban Planner, City of Richmond, pers. comm., 1982.

SECTION V: PUBLIC USE AND ACCESS

Chapter 1. RECREATIONAL USE OF THE EAST BAY SHORELINE

Grant Edelstone

Chapter 2. ACCESS ALONG THE EAST BAY SHORELINE

Dexter Chan

Chapter 1

RECREATIONAL USE OF THE EAST BAY SHORELINE

Grant Edelstone

Introduction

Recreation, doing something, pleasant, refreshing, and different from how a person spends most of his time, greatly contributes to a person's health. The combination of the San Francisco Bay and its shoreline is conducive to many forms of recreation. If the proposed East Bay Shoreline Park becomes real, then the planners ot ifs facilities and programs will have to know of its potential users' recreational needs. To gain this information, the recreation planners could survey users "of existing Bay shore parks, marinas, and other recreational facilities and a general sample of the Bay Area population, including many who presently don't use the Bay shore . . ." (BCDC, 1968, p. 2). This paper describes present recreational uses of the East Bay shoreline, future changes that would affect present recreational uses, and present users' potential recreational uses of the shoreline.

Previous Recreation Needs Studies

Since the 1968 study, Recreation on and around San Francisco Bay, one study in California (DPR, 1982), one in the Bay Area (BOR, 1977), and two in the East Bay (EBRPD, 1976; ABAG, 1973) provide information on users and nonusers of indoor and outdoor recreational areas. These studies have shown that certain factors limit a person's choice of and frequency of participation in a recreational activity. These barriers, or "restraints . . . preventing desired participation in a specific recreation activity" (DPR, 1982, p. 39), include: preferences and physical ability; amount of leisure time and income, the weather, and accessibility of recreational facilities (BCDC, 1968), both in terms of the means to get there (see paper by Dexter Chan) and in terms of awareness of the availability of recreational resources (BOR, 1977), fears for personal safety, amount of necessary skill or equipment, need for a companion, perceived discrimination, and the adequacy of facilities, in terms of what is offered and its appearance (DPR, 1982).

Some members of the following groups have special needs and a greater difficulty overcoming these barriers, with the result of less participation in most recreation activities: California's blacks, Hispanics, Filipinos, disabled, and elderly (DPR, 1982); the Bay Area's elderly, disabled, tiny tots, teens, Chinese, Mexican-Americans, and other ethnic and minority people (BOR, 1977); and the East Bay's blacks, Latinos, Native Americans, and Asians (ABAG, 1973); and the elderly auto-less, and disabled (EBRPD, 1976, p. xiv). While in general these people participate less, the factors affect each group member differently. Present recreation activities of these people often differ from their preferred activities; they would like to do more park-, wilderness-, and nature-oriented activities (ABAG, 1972, pp. 20-23; DPR, 1982, p. 18).

These people may be less able to afford the cost of equipment, transportation, and learning a new skill. Low-income people can easily fish from a shore or pier, but they have difficulty affording expensive forms of recreation, such as yachting. A recreational area may be less accessible to a person in a wheelchair and to someone who depends on public transit. A person is sometimes unaware of a recreational area because he is hearing-impaired, doesn't speak English, or the recreation staff doesn't speak his language.

People in these social groups may participate less because they don't feel comfortable in or identify with many outdoor recreational areas. If a person perceives discrimination due to age, disability, economic status, or ethnicity, or feels unsafe at a recreational area, he or she probably will not return.

With the removal or reduction of barriers, people may participate more in outdoor recreation. Disabled people may need only modifications of existing shoreline recreational areas, to accommodate their degree of physical ability (Fitzgerald, 1982, pers. comm.). For example, having something hard under sand at a beach would prevent wheelchair wheels from sinking in. A ramp could go from the shoreline out 5-10 feet, for a person in a wheelchair to wet his legs. Trails need to be level and hard for wheelchairs.

The types of recreational facilities needed in California depend on changes in the size of the population and its ethnic, sex, and age distribution, education and occupation patterns, the advent or demise of fad activities, and changes in the factors influencing recreation demand (DPR, 1982). In California, the aging population plus the unexpected increase in average income will cause the greatest growth in nonstrenuous outdoor activities (DPR, 1982). For Californians, a "primary urban recreation need . . . was for nature-oriented parks in and near

metropolitan areas" (DPR, 1982, p. 27). For Bay Area residents, the "primary urban recreation need . . . [was] for the establishment of more parks (in the sense of an unstructured public open space) suitable for all ages, for socializing as well as recreating) within the community or neighborhood" (BOR, 1977, p. 5). Primary among the experiences of visitors to the East Bay Regional Park District parks are the activities available in the parks and the natural environment of the parks (EBRPD, 1976).

Methods

It is difficult to learn people's recreation needs. For example, most people do not communicate their views to recreation planners or attend public meetings about proposed recreation facilities. Those who do attend meetings usually represent groups, and "a group or neighborhood that lobbies more than another, less organized group may have its needs met, instead of those with the greatest need" (BOR, 1977, pp. 47-48). Additionally, many people aren't in groups. I wanted to learn the needs of present shoreline users, who may not have attended the workshops on the proposed East Bay Shoreline Park.

Using a questionnaire, shown in the Appendix, with short, clear, relevant, nondouble-barreled, posivite, and unbiased questions (Babbie, 1975), I interviewed forty-one shoreline visitors in Emeryville, Berkeley, Albany, and Richmond. I usually interviewed people on Sunday afternoons, except for the Point Isabel interviews, which were on a Wednesday afternoon. The weather was usually windy and cool, and it occasionally drizzled on that Wednesday.

At each site, I randomly chose people or small groups of people from among those I observed doing a particular activity. I assumed that, for example, the picnickers I interviewed were representative of all the other picnickers at a site. I also assumed that the interviewees were representative of shoreline visitors. My sample of people is not statistically random. My survey is also biased toward present users. While I talked with only four people who presently either don't or infrequently use the shoreline, the forty-one interviewees were of different ages, degrees of physical ability, and ethnic groups.

I sometimes clarified questions and offered sample answers, to help someone understand the questions and get started thinking about some of the open-ended questions, but I don't think my doing so made much difference in people's responses, since most people had opinions. I did not interview someone from each type of recreational activity I observed.

Survey Results

A site-specific summary of interviewees' shoreline uses, a general summary of their responses to nonsite specific questions, and their volunteered comments appears in the following text. Interviewees made the unreferenced quotations. Appendix 2 shows site-specific answers to close-ended questions. Appendix 2 lists site-specific changes affecting shoreline uses.

Recreation in Emeryville

"The Point," at the Emeryville Marina (see map, p. vi), has trees, grass areas with picnic tables somewhat sheltered from the wind, a shoreline trail with some benches along it, a pier, and a bird refuge. The city of Emeryville offers a summer fishing program for youth and senior citizens.

The Point's location, view of the bay, cleanliness, freshness, quietness, and serenity attracts people. "It is away from it all, yet still with people around and untampered with;" like "being away from people and seeing a little bit of nature." At the point, the most popular activities that people mentioned are viewing, hiking or walking, and picnicking.

At the Emeryville Crescent sculpture marsh, people enjoy hiking or walking, viewing the sculpture and birds, and studying the birds. (For more information on recreational uses of the Crescent and on the conflict between recreation and wildlife habitat conservation, see paper by Lisa Cohen). In addition to the potential uses of Emeryville's shoreline, as listed in Appendix 2, most people would like an environmental education center at the Crescent. Some comments included: "Most people don't think anything is in the bay or marshes, but it is a beautiful bay, with much life. It is nice to watch people enjoying the bay life;" "One modest center could serve the whole East Bay shoreline;" "This area may be too small for such a center and enough man-made things may already exist." More than half the interviewees wanted the sculptures left as they are.

Recreation in Berkeley

The city of Berkeley offers recreation programs at the Berkeley Pier, Berkeley Marina, Shorebird Park, and Aquatic Park (see map, p. vi). Its goal is to have a variety of low impact programs (usually for small groups of people and not happening every weekend) geared to the Berkeley community's youth and seniors (City of Berkeley, 1982). The marina has a public dock, a private yacht club, and two parks. The pier has a lookout platform, benches, and night lighting (Kunkel, 1980). The "Marina Experience Environmental Education Program" has ecology walk

field trips around the piers and beach area for Berkeley Unified School District elementary students, weekend extra credit projects for junior high school students, and lunch, walk, and talk programs for senior citizens (City of Berkeley, 1982). Short fishing trips for low-income children and seniors leave from the marina on commercial boats. Project Interdependence is desighed to train disabled people to interpret the bay's history and biology.

Shorebird Park has a beach and "a most attractive set of mounds and grassy dells, with hidden picnic tables, a jungle gym and restroom facilities . . ." (Kunkel, 1980, p. 12). At Shorebird Park, Berkeley Adventure Playground opens in the spring; in the summer a day camp opens, where the marina environment and ecology are featured to participants, including disabled children and teens. A free water ski program occurs at Aquatic Park. Near Shorebird Park is the Cal Sailing Club area, where people also windsurf. People fly kites in the meadow adjacent to University Avenue.

Aquatic Park has paved trails, a Dyna course to improve the cardiovascular system, one of the few Disc (frisbee) Golf courses in the Bay Area, a jungle gym, picnic tables, a barbeque area, waterskiing, windsurfing, sailing, and rental non-power boats. Aquatic Park attracts people because it is relatively quiet, except for freeway nose, safe, close to home or work, a pleasant place to relax and play with your dog, and it has a nice setting, water, wildlife, such as migratory water-fowl (Kunkel, 1980), boating, and few planned activities. For one person, Aquatic Park "fits my needs perfectly." The most frequently mentioned activities are hiking or walking, jogging, picnicking, and viewing.

People visit the Berkeley Pier and Marina area because it is peaceful and quiet, close to home or work, a good place to fish, different from other recreational areas, a special place, offers a variety of activities, and "it gives you a sense of being away." The most popular activities are hiking or walking, viewing, and, from my observations, fishing. Many people fish on the pier, some for subsistence.

In addition to the potential uses shown in Appendix 2 for Berkeley sites, most interviewees either strongly agreed or agreed that most East Bay residents would enjoy a beach between Ashby and University Avenues, and almost as many said they would be likely to use such a beach. Some interviewees thought a beach at this location would be nice to sit on, but it would have to be sheltered from the freeway. People enjoy walking on the exposed areas of shoreline at low tide. One person thought the area was too cold for a beach, while another thought "people

would be flocking down to a beach and that a beach would improve the shoreline."

People like the Brickyard, a landfill primarily covered with bricks and slabs of concrete, along with some vegetation, because "it is the Brickyard, not the Marina.' Its roughness or naturalness makes it fun to be there: "It's like going camping, only you are just down the street from home." Present recreation activities include fishing, hiking or walking, dog walking, and viewing.

North Waterfront Park, on top of part of the Berkeley land fill, has flat grass areas, some landscaped areas, a drinking fountain, benches, picnic tables, barbeques, and gravel trails along the shoreline. The nearby sailing school office has restrooms. People enjoy the open look and uncrowded feeling of the park. They like watching the boats and "relaxing in the sun by the sea in a natural place." At the park, "the shoreline and water is relaxing; it relieves stress, like a tranquilizer without the drugs." People primarily enjoy viewing and picnicking.

Recreation in Albany

Point Fleming (see map, p. vi), or "behind the racetrack," has two deteriorating fishing piers and some exposed mud or sand areas at low tide. People fish here. Less than half the interviewees wanted an environmental education center at the Albany mudflats and Hoffman marsh, and an equal number were not familiar with this part of the shoreline.

Recreation in Richmond

The East Bay Regional Park District's Point Isabel Regional Shoreline Park (see map, p. vi) has grass areas, a paved shoreline trail, picnic tables, a drinking fountain, and restrooms. People enjoy the park's beautiful view, peace and quiet, and its being next to the ocean, uncrowded, isolated, close to home or work place, cool for jogging, and windy enough for kite flying. The most popular activities include picnicking, viewing, and jogging.

At all of the interview sites, people mentioned most of the activities I listed, except for shellfish harvesting and swimming or wading, and they also mentioned photography, reading, kite flying, shell collecting, and ball games. I observed all the mentioned activities at the shoreline. Many people didn't have a most important recreational activity. All the activities seemed important to those who did them.

Changes Affecting Present Recreational Uses

At all sites, most people had difficulty thinking of changes that would affect their use of the shoreline. Many people wanted each site left alone. Changes that would enhance present recreational activities were easier for most people to think of than changes that would decrease use.

In general, better maintenance, more clean-up of litter, more places to walk, and having restrooms, refreshment stands, and offshore parking would increase most people's recreational use of the interview sites. Increased usage, decreased access, pollution, and the addition of any commercial or industrial developments would generally decrease people's recreational use.

Potential recreational uses of the interview sites include having educational displays, a museum of natural science, or tide pools that would show, especially to children, the fish people catch and other marine and wetland life. Other people wanted play areas for children disinterested in their parents' activities.

Almost everyone either strongly agreed or agreed that it is important to preserve or restore, when necessary, city creeks and streams. About half the interviewees were aware of a creek near their home and almost all of these people named the creek or a street running parallel to it.

Shoreline Visitors

To travel to each site, almost all people drove, while a few people biked or walked, and none used public transportation. Although most people felt that travel to the shoreline was easy now, some people said that if travel were easier to Point Fleming, which has vehicle access only on Sundays, and to the Berkeley Marina area and North Waterfront Park, which are difficult to get to by bike, then they would visit more often. Most interviewees were local visitors, and they travelled one to five miles from home or work, but a few travelled much more than ten miles.

The amount of time people spend per visit depends on the weather. Most interviewees had visited the corresponding interview site before and they usually spent less than two hours per visit. Those who fish sometimes spent eight or nine hours per visit. In summer, joggers and dog walkers visit a particular site once a day. One person even visits Point Fleming at night. In winter, most people visit the shoreline much less, but the joggers and dog walkers still visit almost every day. Most interviewees visit other parts of the East Bay shoreline, especially the Berkeley Marina and Berkeley Pier areas.

More than half the people said there were not enough recreational areas along the shoreline near their homes. A few felt there were enough. Most people either strongly agreed or agreed that most East Bay residents would enjoy an East Bay Shoreline Park, and almost as many said they would be likely to use such a park there.

People rely upon driving to get to a particular site and travel short distances from home or work. Some people regularly use a particular site in most kinds of weather. There was much local use of the East Bay shoreline. For example, two people from Albany were visiting the Point. There was also some distant regional use as people from San Jose and Mountain View were at the Point. If travel were easier for those who bike or walk to the shoreline, local use would probably increase.

A beach along the East Bay shoreline may or may not get much use, depending on its location and people's preferences. While swimming and wading in the bay is limited by the water's coldness, bay beach use is popular, even when other swimming and sun-bathing places are available in nearby inland locations (BCDC, 1968). Beach use of the bay shore would increase if "water conditions were improved and if bay shore parks were increased and improved" (BCDC, 1968, p. 9). Criteria for location of beaches include having protection from wind, having the warmest waters of the bay, and being convenient to major population centers (BCDC, 1968).

The combining of recreation with environmental education could enhance people's recreation and make them more aware and concerned with preserving the bay wetlands. Nature exploring, by wildlife photography, bird watching, and educational study of nature, is a desirable means of providing public education about the natural environment and it doesn't decrease the stock of wildlife, like fishing or hunting (BCDC, 1968). It is difficult to provide access to ecologically sensitive areas like the Emeryville Crescent. Although access to intertidal areas at the Hayward Regional Shoreline led to a decrease in misuse of the area (Koos, 1982, pers. comm.), people trample the Crescent marsh plants and disturb the shorebirds. Less sensitive areas, where people birdwatch, fish and visit marshes, could be spots for such education.

In addition to having a beach and environmental education along the shoreline, it is possible to preserve, provide access to, and create parks around the few remaining stretches of open creeks close to the shoreline. For example, the open space surrounding parts of Codornices Creek, just east of the Eastshore freeway,

could be developed into a park (see paper by Arthur Molseed).

Although most interviewees thought most East Bay residents would enjoy an East Bay Shoreline Park and a beach between Ashby and University Avenues, I can't use present users' views to talk about present nonusers' views.

Conclusions

People enjoy the shoreline and their various present activities along it. Their activities are important to them, and they don't want changes at their place of recreation. What would enhance some present users' activities would decrease other present users' activities. Also, a user's potential activities may decrease another's present activities. Changes to existing recreational areas and the creation of new areas will be difficult to plan for, since people have different preferences. The various locations along the East Bay shoreline are visited by people from the adjacent cities, but also from more distant locations.

My findings, and those of the previous studies, which are similar to mine, if applicable to the East Bay shoreline, suggest that the proposed East Bay Shoreline Park would get much use.

Recommendations

In addition to present shoreline users' needs, planners must consider the needs of nonusers who would, if conditions were right, become more frequent users. I hope that planners of the potential East Bay Shoreline Park will design an area that all types of people will find accessible, feel comfortable in, identify with, and want to visit. The park should be attractive, safe, and designed for activities that most people, including families, can participate in. Perhaps an unstructured, nature-oriented park, with picnic areas, hiking trails, children's play areas, refreshment stands, campsites, beach and related activities, and educational displays would meet most people's needs.

Appendix 1. Sample Questionnaire and Tabulation of Answers. The letters indicate interview sites: Emeryville Crescent sculpture marsh (ECS), The Point (P) at the Emeryville Marina (EM), Aquatic Park (AP), Brickyard (By), Cal Sailing Club Area (CSC), Adventure Playground at Shorebird Park (SP), Berkeley Pier (BP), Berkeley Marina (BM), North Waterfront Park (NWP), Point Fleming (PF), and Point Isabel (PI). These locations are shown on the map, page VI. The number at the top of each column is the number of interviews at that site. The numbers in each column are the numbers of answers to each question.

SURVEY OF VISITORS TO THE EAST BAY SHORELINE

General Instructions: Most of the questions below may be answered choosing one of the listed answers; other questions ask for your own answers. Please make additional comments whenever you wish to do so.

I. TRAVEL

In this section, we would like to know how you travel to here, how much time you spend per visit, and how often you visit the East Bay Shoreline (between the Bay Bridge and Hoffman Blvd. in Richmond).

EC (1)	P (4)	AP (13)	CSC (1)	SP (1)	BP (5)	BM (1)	By (3)	NWP (5)	PF (2)	PI (5)	
											1. How did you get here today?
0	3	7	1	1	5	1	3	4	2	5	()car
0	0	0	0	0	0	0	0	0	0	0	()public transportation
0	0	2	0	0	0	0	0	1	0	0	()bike
1	1	4	0	0	0	0	0	0	0	0	()walked
											2. How far from home (or work) did you travel to come here?
1	1	5	0	0	1	1	0	0	1	1	()less than one mile
0	1	7	1	1	2	0	2	3	1	4	()one mile - five miles
0	1	1	0	0	0	0	0	1	0	0	()five miles - ten miles
0	1	0	0	0	2	0	1	1	0	0	()more than ten miles
											3. What town or city do you live (or work) in?
0	1	1	0	0	1	0	1	1	0	0	()Oakland
1	1	1	0	0	0	0	0	0	0	0	()Emeryville
0	0	9	1	1	2	0	2	3	1	0	()Berkeley
0	1	0	0	0	0	0	0	0	0	1	()Albany
0	0	1	0	0	0	0	0	0	1	1	()El Cerrito
0	0	1	0	0	0	0	0	0	0	3	()Richmond/Richmond Annex
0	1	0	0	0	2	1	0	1	0	0	()Other: Mountain View, San Jose, Vallejo, Sacramento, non-Ca.
											4. How much time do you spend per visit?
0	0	0	0	0	0	0	0	1	0	0	()less than 30 minutes
1	2	7	0	1	1	1	0	0	0	1	()30 minutes - one hour
0	0	3	1	0	0	0	1	2	1	2	()one hour - two hours
0	2	3	0	0	3	0	2	2	1	2	()more than two hours
											5. Is this your first visit here
0	2	2	0	0	2	0	0	2	0	0	()yes
1	2	11	1	1	3	1	3	3	2	5	()no----> If no, how often do you visit in:
											Summer? Winter?
1,	0,0	3,3	0,0	0,1	1,2	1,0	0,0	0,0	0,0	0,0	()....less than once a month....()
0,0	0,1	2,1	0,1	1,0	0,0	0,0	0,0	1,0	0,1	0,0	()......about once a month......()
0,0	0,0	1,2	0,0	0,0	1,0	0,0	1,0	1,0	0,0	1,0	()....one to ten times a month..()
0,0	0,0	2,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	1,0	()....ten to 15 times a month...()
0,0	2,1	2,3	0,0	0,0	1,1	0,0	2,1	0,1	1,0	0,0	()....one to four times a week..()
0,0	0,0	1,2	1,0	0,0	0,0	0,0	0,0	0,0	1,0	3,3	()....four to seven times a week()
											6. If travelling to here were easier, would you visit more often?
0	0	5	0	0	1	0	1	2	1	0	()yes
1	0	2	0	0	0	0	0	0	0	0	()no
0	4	5	1	1	2	1	2	2	1	5	()it is easy now
0	0	1	0	0	2	0	0	1	0	0	()not applicable

EC (1)	P (4)	AP (13)	CSC (1)	SP (1)	BP (5)	BM (1)	By (3)	NWP (5)	PF (2)	PI (5)
---	---	1,0	0,0	0,0	0,0	0,0	0,0	0,1	0,0	0,0
0,0	0,0	1,0	0,0	0,0	1,1	0,0	0,0	0,0	0,0	0,0
0	0	---	0	0	0	0	0	2	0	0
0,0	0,0	0,1	0,0	0,0	1,0	0,0	0 0	3,2	0,0	1,0
0,1	1,3	4,6	0,0	1,0	-,1	0,-	1,2	4,5	0,1	0,1
0	0	1	0	0	1	0	0	---	0	0
0,0	0,0	1,0	0,0	0,0	0,0	0,0	0,0	1,1	-,0	0,0
0,0	1,0	0,0	0,0	0,0	1,0	0,0	0,0	1,0	0,0	0,0
0	0	1	0	0	0	0	1	1	0	---
0	1	5	1	0	2	1	1	0	0	3

7. What other parts of the East Bay shoreline do you visit?
   ()Emeryville Crescent, ()The Point
   ()Ashby Spit, ()Riprap along Frontage Road
   ()Aquatic Park
   ()Shorebird Park, ()Horseshoe Park
   ()Berkeley Pier, ()Berkeley Marina
   ()North Waterfront Park
   ()Point Fleming, ()Golden Gate Fields
   ()Albany Mudflats, ()Hoffman Marsh
   ()Point Isabel
   ()none

II. Recreational Use

In this section, we would like to know what you enjoy doing here and at other places along the East Bay Shoreline. Also, we would like to know what future changes of the shoreline you would like and dislike.

8. From the following choices, please indicate what you like to do here. Choose as many activities as you do here. Next, rank rank your most important and second most important activites. #1,#2
   ()Nature Study
   ()Picnicking or Eating lunch
   ()Hiking or Walking
   ()Jogging
   ()Biking
   ()Sailing or Windsurfing
   ()Fishing
   ()Swimming or Wading or sunbathing
   ()Dog Walking or Playing with dog
   ()Viewing
   ()Shellfish Harvesting or Worm Collecting. If you harvest, what do you do with the shellfish?
      ()food
      ()bait

EC	P	AP	CSC	SP	BP	BM	By	NWP	PF	PI
1,0,0	1,0,0	3,2,0	0,0,0	0,0,0	1,0,0	1,0,0	1,0,0	0,0,0	0,0,0	1,0,0
0,0,0	3,0,1	7,1,0	0,0,0	0,0,0	0,0,0	0,0,0	0,0,0	4,1,1	0,0,0	1,0,0
1,0,0	3,2,0	9,1,3	0,0,0	1,1,0	2,0,0	1,0,0	2,0,1	3,2,0	0,0,0	4,0,1
0,0,0	1,0,0	4,2,0	0,0,0	0,0,0	0,0,0	0,0,0	0,0,0	1,1,0	0,0,0	2,0,0
0,0,0	1,0,0	4,0,1	0,0,0	1,0,0	0,0,0	0,0,0	0,0,0	1,0,0	0,0,0	0,0,0
0,0,0	0,0,0	0,0,0	1,1,0	0,0,0	1,0,0	0,0,0	0,0,0	1,0,0	0,0,0	0,0,0
0,0,0	1,1,0	0,0,0	0,0,0	0,0,0	3,3,0	0,0,0	2,2,0	2,0,0	2,0,0	1,0,0
0,0,0	0,0,0	1,0,0	0,0,0	0,0,0	0,0,0	1,0,0	0,0,0	0,0,0	0,0,0	0,0,0
0,0,0	0,0,0	4,1,0	0,0,0	0,0,0	1,0,0	0,0,0	1,0,0	0,0,0	0,0,0	2,0,0
1,0,0	4,0,2	5,0,1	0,0,0	1,0,0	2,0,0	1,0,0	2,0,1	5,1,0	0,0,0	4,0,1
0,0,0	0,0,0	0,0,0	0,0,0	0,0,0	0,0,0	0,0,0	1,0,0	0,0,0	0,0,0	0,0,0
0,0,0	0,0,0	0,0,0	0,0,0	0,0,0	0,0,0	0,0,0	0,0,0	0,0,0	0,0,0	0,0,0
0,0,0	0,0,0	0,0,0	0,0,0	0,0,0	0,0,0	0,0,0	1,0,0	0,0,0	0,0,0	0,0,0

---

8. What changes at this part of the shoreline might enhance your present recreational use(s) of this area?
10. What changes here might decrease your present recreational use(s)?
11. If you could make any changes here you wanted, how else might you recreationally use this part of the shoreline and what changes would you make?
12. What is it about the shoreline that brings you here, rather than other recreational places in the area?
13. Do you feel there are enough recreational areas along the shoreline near your home? (5)yes (25)no (6)no answer (5)doesn;t apply
14. Do you think the Emeryville Crescent sculptures should be: (2)torn down (1)limited in their location (27)left as is (4)expanded to other areas of the Crescent (8)no answer/doesn't apply
15. Beside each of the statements presented below, please indicate whether you Strongly Agree(SA), Agree(A), Disagree(D), Strongly Disagree(SD), or Don't Know/Undecided(U), No Answer/Not Apply

SA	A	D	SD	U	NA	
(10)	(24)	(1)	(0)	(1)	(5)	a. Most East Bay residents would enjoy an East Bay Shoreline Park.
(18)	(16)	(1)	(2)	(0)	(5)	b. I would be likely to use such a park.
(15)	(13)	(3)	(4)	(1)	(5)	c. Most East Bay residents would enjoy a beach between Ashby and Univ. Aves.
(10)	(13)	(4)	(5)	(3)	(6)	d. I would be likely to use a beach there.
(27)	(6)	(0)	(0)	(1)	(7)	e. It is important to preserve, or restore, when necessary, city creeks.

16. Are you aware of any creeks near (within one mile) of your home? If yes, what is the name(s) of that creek(s) or a street(s) running parallel to it? (9)Strawberry (2)Gilman St. (1)Monterey St. (1)El Cerrito Plaza (1)Monterey St. (1)El Cerrito--Albany line (2)spruce St. near San Pablo Dam (1)Diamond (1) Huber Park
17. Would you like there to be an environmental education center at the: Emeryville Crescent? (24)yes (2)no (15)doesn't apply/know Hoffman Marsh--Albany Mudflats? (15)yes (2)no (24)doesn't apply/no answer

Appendix 2 Changes affecting recreation along the East Bay shoreline

	changes that would enhance present recreational uses	changes that would decrease present recreational uses	potential recreational uses of and changes to this area
EC	*don't make any changes	*anything commercial	*no answer
P	*having more parking and walking areas *having more of the attractive disposal units, so people won't throw stuff into the Bay	*adding commercial developments, like arcades or restaurants *adding industrial developments *increased use *any smell or dirtiness	*having displays or a museum of natural science to explain what is in the Bay, especially for children
By	*cleaning up some of the junk *making better trails *adding a bait shop and refreshment stand	*having a park and bathrooms, as this would remove the rough feeling of the area	*having a park with bathrooms, grass, picnic tables, places to jog, and parking for cars
AP	*having people clean up after their dogs *maintaining the area better, like cutting weeds in middle of Disc Golf Course more frequently, trimming the trees, and repairing the roads which become muddy and have potholes filled with water during the winter *repairing damage from vandals *having lights and a police patrol *having a drinking fountain and restrooms at the Bay St. entrance *improving the entry road from Bay St. and having access more clearly marked at Channing *moving benches and tables further back from the water, as present location gets too windy *blocking off area from freeway noise/pollution	*having any baseball, football, soccer, or other ball fields *having any development on the Disc Golf Course *adding any buildings *having too many more people at the park *having boat races *having troublemakers	*going swimming, especially during summer *having rowboats and pedal-boats for rent *having more boating and horse-back riding *having a garden *having swings and a slide for children
CSC	*blacktopping the parking lot and putting in a telephone, restrooms, showers, and a sauna *enlarging the area and having a deck on top of the building, for viewing	*further polluting of the water, as this would decrease accessibility	*crabbing, if water were cleaner *having a driving and practice range, for golf and baseball
BP & BM	*more clean up of garbage in parking lots and along trails *more garbage cans on the pier and better maintenance of lightbulbs on the pier *more fish and more fishing instruction on the pier, especially for children *more grassy areas and more shelter from wind *more trails that are not so rocky and are five-ten miles in length. *having a refreshment stand	*more restaurants	*having play areas for kids disinterested in their parents' activites *having nature education, especially for children, perhaps through a tide pool that would collect different types of marine life or a display board *having coin operated binoculars, to see points of interest *having an espresso shop
NWP	*having sand by the water and a natural shelter from the cold, but sometimes pleasant, breeze *having more places to walk, restrooms, barbeque areas, picnic tables, and improved transportation to the park *having a security person or caretaker, to help someone identify with this isolated park	*over-improving the park *having any buildings or a concession stand	*Having swings or a jungle gym *having an educational display board to identify birds you see *Having benches every 50 feet along trails, for senior citizens *having a concessions stand *having volleyball, tennis, softball
PF	*having drinking fountains, bathrooms, and lights for night fishing and rehabilitating the pier	*decreased access	*having grass areas, barbeque pits, picnic areas and offshore parking
PI	*having more paths and a snack bar *having more grass South of the park *keeping cars off the dirt West of restrooms *having towers 15 feet high to increase viewing *having something to help people know what kind of fish they are catching	*putting an oil rig off the Point or having any buildings in the grass area *letting this beautiful scenic area go to waste or poor water quality *allowing the use of motorcycles	*having a par course *having a carnival on the grass *having something like Knowland Park, where the kids could see the marine life and feed ducks

REFERENCES CITED

Association of Bay Area Governments (ABAG), July, 1973. Recreation preferences of minority peoples in the East Bay Area: A pilot study: Berkeley, ABAG, 146 pp.

Babbie, Earl R., 1975. The Practice of Social Research: Belmont, CA, Wadsworth Publishing Company, Inc., 511 pp.

Bureau of Outdoor Recreation (BOR), Pacific Southwest Regional Office, 1977. National Urban Recreation Study: San Francisco, Oakland, San Jose: National Park Service, Denver Service Center, 154 pp.

California Department of Parks and Recreation (DP), February, 1982. Recreation Needs in California: Report to the Legislature on the Statewide Recreation Needs Analysis: Sacramento, CA, 39 pp.

City of Berkeley, February-March, 1982. Marina Boating Program Report. In office of Kirk Chiapella, Recreation Coordinator-Aquatics.

East Bay Regional Park District (EBRPD), 1976. The East Bay Regional Park District Need and Demand Survey: San Francisco, Tyler Research Associates, 14 pp.

Fitzgerald, Ann, Mainstream Coordinator, Berkeley Outreach Recreation Project. Personal Communication, 4/82.

Koos, Peter, Principal Planner, East Bay Regional Park District. Personal Communication, 4/22/82.

Kunkel, Erika, 1980. A Day at the Berkeley Bayfront: An Environmental Guide: Berkeley, Hillview Press, 19 pp.

San Francisco Bay Conservation and Development Commission Staff (BCDC), January, 1968. Recreation on and around San Francisco Bay, summary report: San Francisco, SFBCDC, Report No. 35, 15 pp.

Chapter 2

ACCESS ALONG THE EAST BAY SHORELINE

Dexter Chan

Introduction

Access to the East Bay shoreline is critical for the future use and value of the area. Its role is intimately intertwined with any plan for the area, especially with regard to the proposed East Bay Shoreline Park with special attention to non-automotive forms of access. Properly planned and developed means of access will serve to enhance the usability of the shoreline.

Access serves as a way of encouraging people to visit an area, and as a means of controlling the number of people and their flow through an area. It can even serve as a way of preventing people from entering an area. All these factors must be taken into account when the potential uses of the shoreline are discussed.

The presence of U.S. Interstate Highway 80 along the entire length of the shoreline study area also requires any comprehensive report to include the possible effects of changes to the highway in relation to the shoreline proposals. Changes are especially crucial at this location since the shoreline's access points are directly related to the highway exits, and I-80 is the primary artery connecting San Francisco with the East Bay.

The California Department of Transportation (Caltrans) has several key goals for this corridor. One of their goals is to increase the capacity of the highway. Another major goal is to enlarge the highway physically as little as possible, to keep down acquisition and construction costs. Thirdly, Caltrans hopes to encourage more riders per vehicle, which would effectively increase the number of people using the highway, but not the number of vehicles (Larson, pers. comm., 1982). Caltrans proposes the use of High Occupancy Vehicle (HOV), or "Diamond" lanes, and the addition of auxiliary lanes to meet these goals. These should increase the flow rate on the highway, thereby increasing capacity over time (Forsen, pers. comm., 1982). Since construction and restructuring of the highway and its on- and off-ramps will be necessary, it is important that we also analyze these proposed changes and how they will affect key access points to the shoreline. Presently, the proposals are

in the draft Environmental Impact Report (EIR) stage and still subject to revisions.

One positive aspect of these proposed changes is that they are occurring at a time when other major changes are being considered along the shoreline by various groups. This permits cooperation between agencies to implement these proposals most efficiently.

The question of providing access, and what type, is critical to each area along the shoreline, especially if it is better not to permit access. This may be the case concerning ecologically sensitive sites such as the wetlands areas.

There are two ways to prevent problems due to access. One, do not allow access of any type in the area surrounding the sensitive areas. The alternative is to construct pathways controlling access. Both of these options will be discussed in more detail in the Powell Street section (and in Lisa Cohen's paper).

The main forms of access addressed in this paper are: automobile, public transit, bicycle, pedestrian, and handicapped; boat access is beyond the scope of this paper.

I would like to acknowledge the staff at Caltrans, especially Krieg Larson, Hilmer Forsen, and Lloyd Wood, for all the cooperation and time they gave me in their efforts to give me the most up-to-date information possible on their proposed designs. The accuracy and detail of the maps would not have been possible without the use of their geometrics. However, the maps in this report may already be out-of-date, since Caltrans has just started writing the draft EIR, and revisions on their plans are occurring constantly.

Present Access

Present access to the shoreline areas (see map, p. vi) was designed primarily with the automobile in mind. However, with the ever-increasing awareness of the price of gas and public transportation, alternative modes have since become very popular. Unfortunately, those people who wish to take advantage of these alternative modes are often discouraged from using the shoreline area due to the difficulty not only in getting there, but also in getting from one area to another.

Bicycles can now safely reach the shoreline only at Powell Street and Gilman Street. For pedestrians none of the access points are extremely safe. Powell Street and Gilman Street are the best available. The handicapped must rely on automobiles,

Dial-a-Ride, or on AC Transit. With AC Transit they are very limited in which areas they may visit. Also available, on a limited basis, is the Dial-a-Ride program; however, this is restricted by funds and the amount of people wishing to visit an area. TABLE 1 rates each access point in terms of variety and safety. Looking at this table, we can see that each access point is best used by cars. This is followed by public transportation, primarily AC Transit, and then bicycles. And lastly are the pedestrians. A brief description of each access point allows a better understanding of these ratings.

	Cars	Pedestrian	Public Transportation	Bicycles
Central	**	0	**	-
Marin	**	0	0	-
Gilman	**	*	*	*
University	**	-	**	-
Ashby	**	0	0	-
Powell	**	*	**	*

** = Best method for access point
* = Not the safest method, but usable
\- = Highly unsafe
0 = None at this point

TABLE 1. Access Ratings for Individual Access points.

Central Avenue

Travelling north to south, we have Central Avenue as the most northerly access point along the shoreline (see map, p. vi). Located at the western end of Central Avenue are the U.S. Bulk Mail Facilities, Point Isabel Regional Shoreline, the Albany mud flats, and Hoffman Marsh. There now exist two means of access to this fairly isolated area, private auto and AC Transit. Bicycle and pedestrian access is very difficult since crosing I-180 (now known as Highway 17) is required, and the only means to do so now at this point is on an overpass with no provisions for such use. Proposals by Caltrans do address this problem (FIGURE 1). It intends to construct a new overpass with a pedestrian walkway and a marked bike lane.

I-80/I-180 (Highway 17) Junction

This junction is approximately one-and-a-half miles south of Central Avenue, feeding cars from I-80 to I-180 (probably better known as Highway 17) and Hoffman

Avenue. Besides being a major junction for automobiles, this interchange, and the streets below it (Marin Avenue and Buchanan Street), serve the most prominent recreation area along the shoreline, Golden Gate Fields (see map, p.241). The congestion on the highway and the neighboring streets during the horse racing season has forced Caltrans to design a way to handle the traffic problems (FIGURE 2). Their present proposal involves:

(1) Eliminating merge lanes at the junction. By eliminating the merge lanes, traffic should flow from the on-ramps and highway lanes together much more easily, reducing the amount of rush hour congestion (Forsen, pers. comm., 1982).

(2) Reducing the amount of street travel necessary in getting to I-180). The reduction of street traffic is always desirable, but by doing this, Caltrans also encourages bikes and pedestrians to use the less congested streets.

(3) Adding auxiliary lanes westbound to Gilman Street. These lanes would run only from one on-ramp to the next. This effectively adds an extra lane for a short distance and allows extra time for drivers to enter and exit the highway (FIGURE 3).

(4) Adding a collector road eastbound. Collector roads are lanes separate from the main body of the highway. In this instance, such a collector road is used as an extra-long eastbound on-ramp from Gilman Street in the hope that it will allow drivers to by-pass the traffic on the highway from Golden Gate Fields during track season (FIGURE 3).

All of these techniques are designed to increase the flow of traffic with as little physical modification as possible. These changes should relieve the present congestion encountered at the end of the racing day and also should adequately handle the increase in traffic when the Albany Marina is constructed.

<u>Marin Avenue/Buchanan Street</u>

These two streets are directly below the I-80/I-180 interchange (FIGURE 2). The major problem at this location is Golden Gate Fields. The traffic problems presented by the track patrons, especially at the end of the racing day, not only

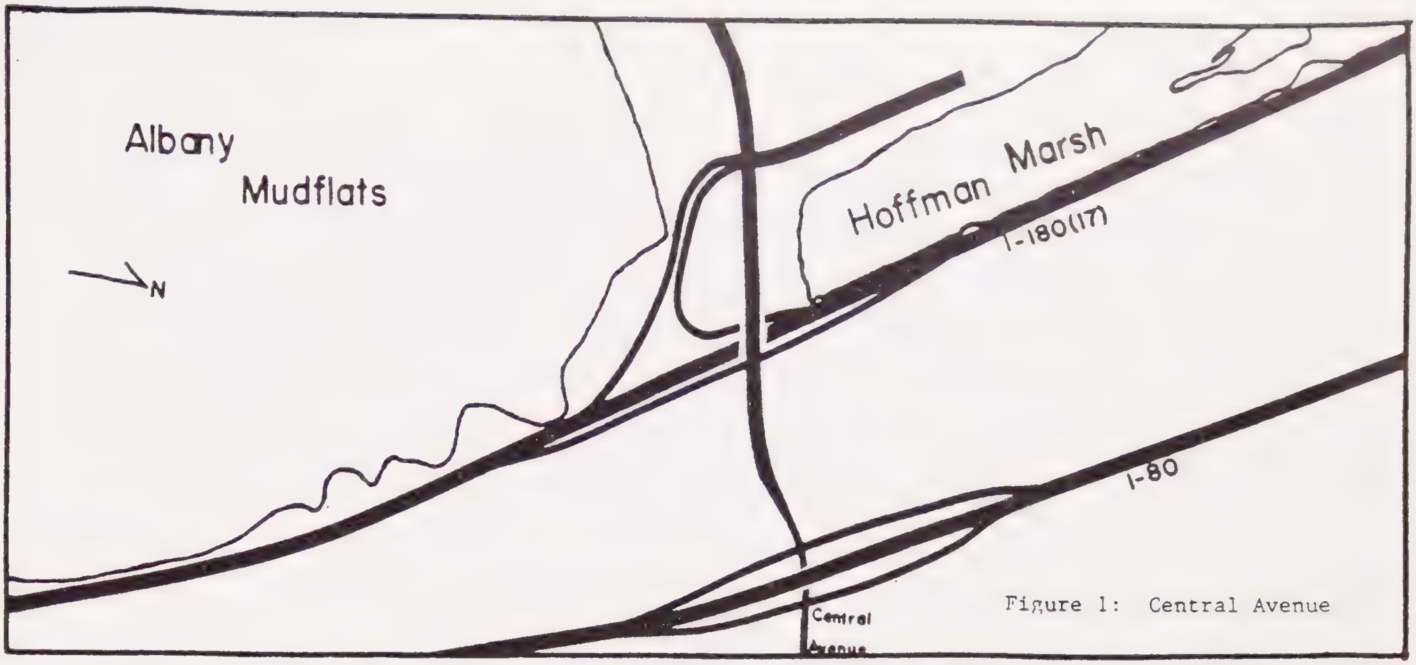

Figure 1: Central Avenue

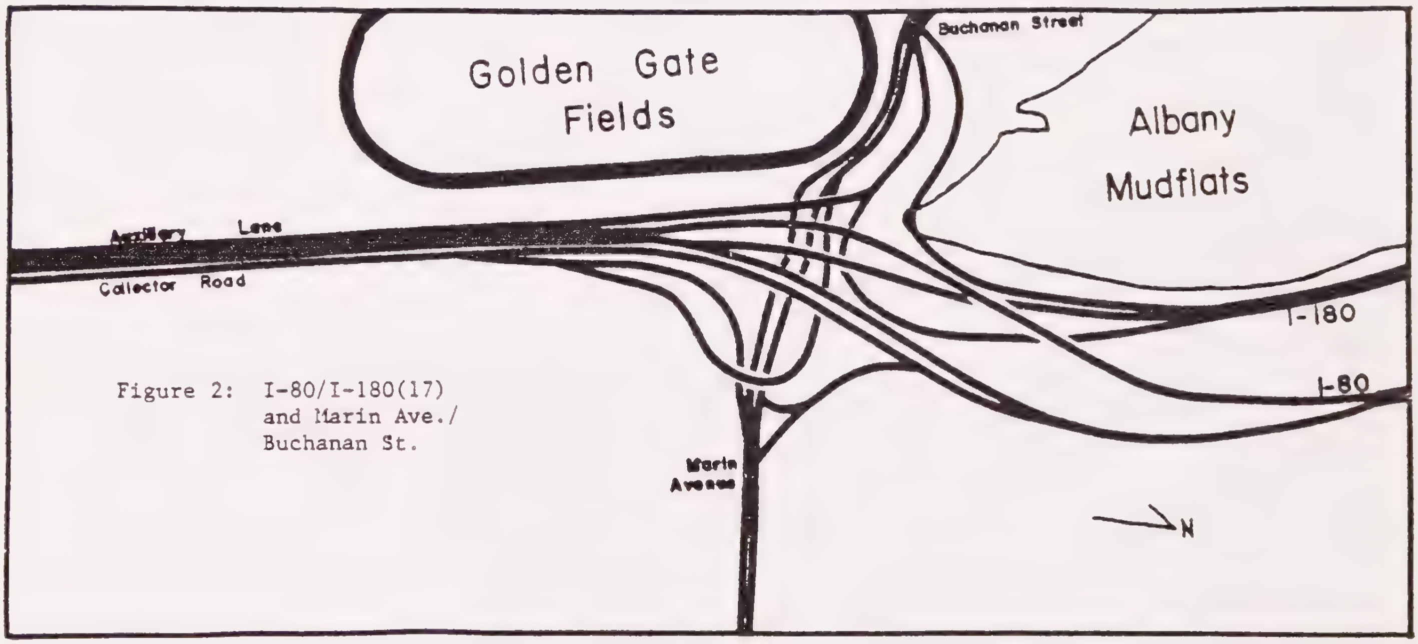

Figure 2: I-80/I-180(17) and Marin Ave./ Buchanan St.

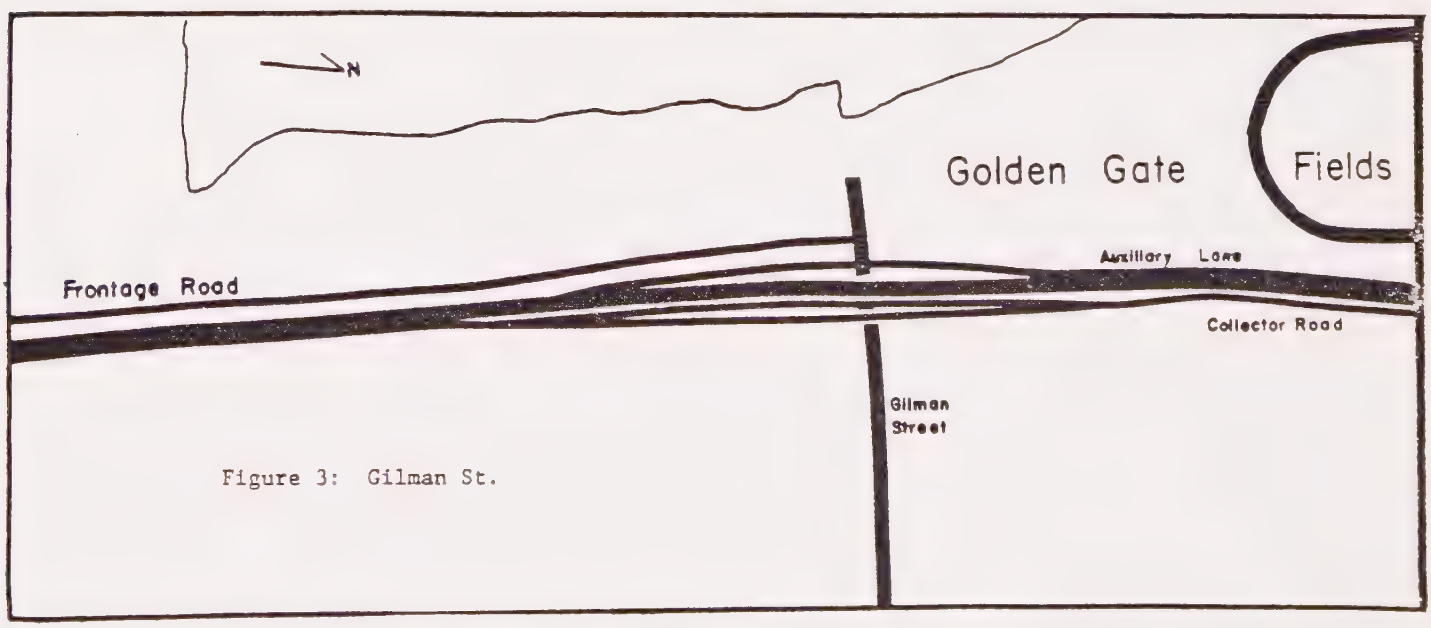

Figure 3: Gilman St.

Source: Base Map: CHMNB; Changes: Preliminary Geometrics from Caltrans

tie up the streets immediately in the vicinity, including Marin Avenue and Buchanan Street, but also highway patterns for miles around. These streets lie below one of the busiest junctions in the East Bay and in this capacity act as a means of supplementing the highway during rush hour. Because they are streets, bicycle access is provided for, since bikes can use the street just as a car would. However, with the amount of traffic flowing through these streets, the relative safety of this form of travel is severely decreased. These streets will also serve the Albany Marina in the future, and the problem could be compounded. Eventually, these traffic problems could discourage people from using the Marina.

A means of handling the situation, short of eliminating either Golden Gate Fields or the proposed Marina, is to provide an "express" lane (or collector road) which would lead directly to the Marina from Marin Avenue, bypassing the congestion from the traffic into Golden Gate Field. This would dovetail with Caltrans' proposal, since it is hoping to persuade the race track traffic to use Gilman Street more, thereby reducing congestion on Marin Avenue/Buchanan Street.

Gilman Street

Located at the southern end of Golden Gate Fields, this street has the most seasonal traffic patterns of all the access points, since it serves as the primary entry and exit point to the racetrack. During the off-season, the "ratings" for bikes and pedestrians as described in TABLE 1 approach a "best method" (**). This improvement is due primarily to the amount of traffic which the area has to handle. Unfortunately, during racing season this capacity is severely taxed, if not surpassed, with only two traffic officers there to control the flow.

The problems which applied to Marin Avenue and Buchanan Street apply doubly here, since now one also has to deal with bicyclists (and pedestrians) who rely on this access point to reach Frontage Road and the shoreline. Combining the bicyclists with the large number of cars which use the area creates a dangerous situation.

Since AC Transit buses stop on the east side of the freeway underpass, passengers have to walk through extremely dangerous intersections to get to the shoreline. This makes pedestrian access at all times of the year less than adequate. Caltrans hopes to relieve the congestion by using collector roads and auxiliary lanes to regulate the flow on I-80, which in turn would reduce the traffic on the

street level (FIGURE 3).

The simplest solution to increase the overall safety of this intersection would be to replace the occasional traffic officers with permanent traffic lights. Also, this hazardous intersection could be avoided by creating other points of access for bicyclists and pedestrians along the shoreline. In the future, Gilman Street will most likely be the northern-most access point to the largest area of the proposed East Bay Shoreline park. Therefore, the question of safety should be dealt with now since modifications are going to be made regardless.

University Avenue

This interchange is perhaps the most critical one along the shoreline, since it serves the Berkeley Marina and will serve the major park area, according to the State proposal. As TABLE 1 shows, access by cars and buses right now is excellent. The problem comes in dealing with bicycle and pedestrian access.

Although Caltrans has provided a stairway and walkway on the south side of the overpass, no controlled access is provided across the off-ramp intersection, through which cars often travel in excess of 30 mph. In addition, no access is provided by either Caltrans or the City of Berkeley across the Southern Pacific Railroad tracks on the east, the Frontage Road-University Avenue intersection to the west of the stairway, and the westbound lane to the Marina.

In a survey conducted for this collection of papers (see Grant Edelstone's paper) comments were made concerning this problem. A biker stated: "It's a pain to get over the bridge (University Avenue Overpass). Maybe there could be a bike lane over the bridge." In response to this, Caltrans has included in its proposed plan, bike lanes with stoplights at each intersection on the overpass and a separate bike trail which detours around the eastern end of the overpass, allowing safe passage for bicyclists across the Southern Pacific railroad tracks (FIGURE 4). Along with the addition of bike lanes and restructuring of the overpass, major revisions are planned for the westbound ramps, especially the off-ramp.

Presently, before reaching the cloverleaf, south-bound exiting traffic must merge with entering traffic. Caltrans plans to relieve the dangerous situation by eliminating the need for this merger. By moving the off-ramp north so that the exit is made directly to University Avenue, the cars need not merge and the cloverleaf ramp in that direction may be eliminated (FIGURE 4).

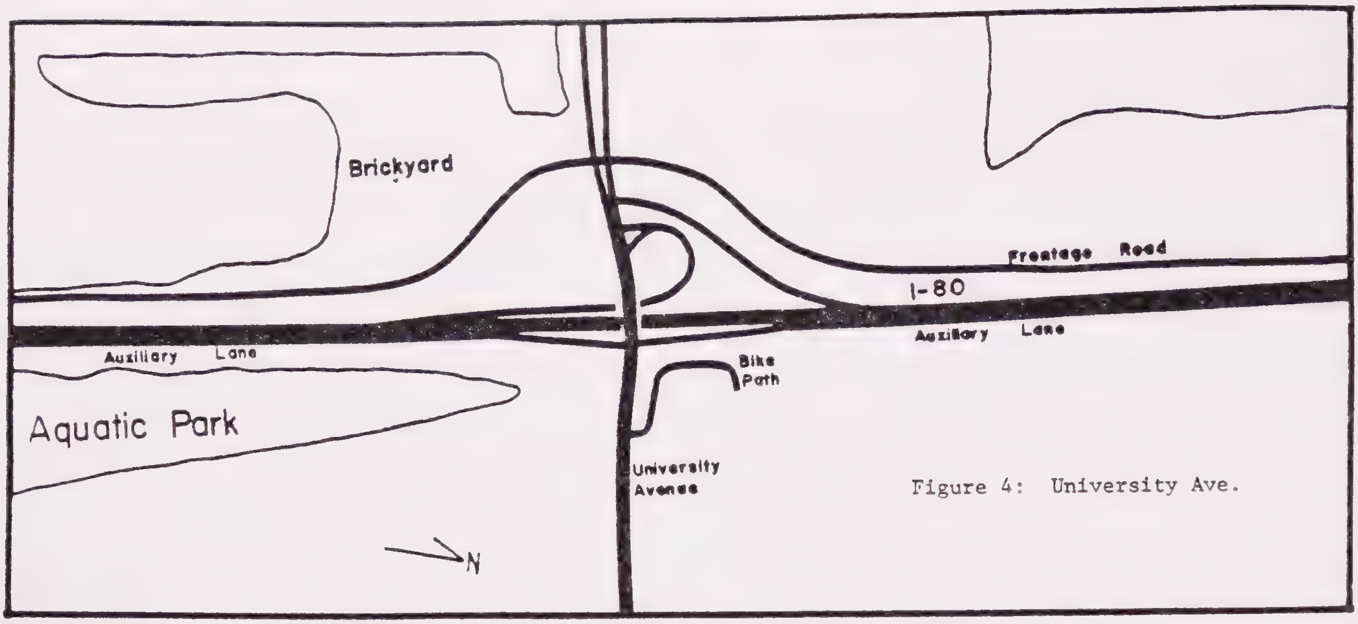

Figure 4: University Ave.

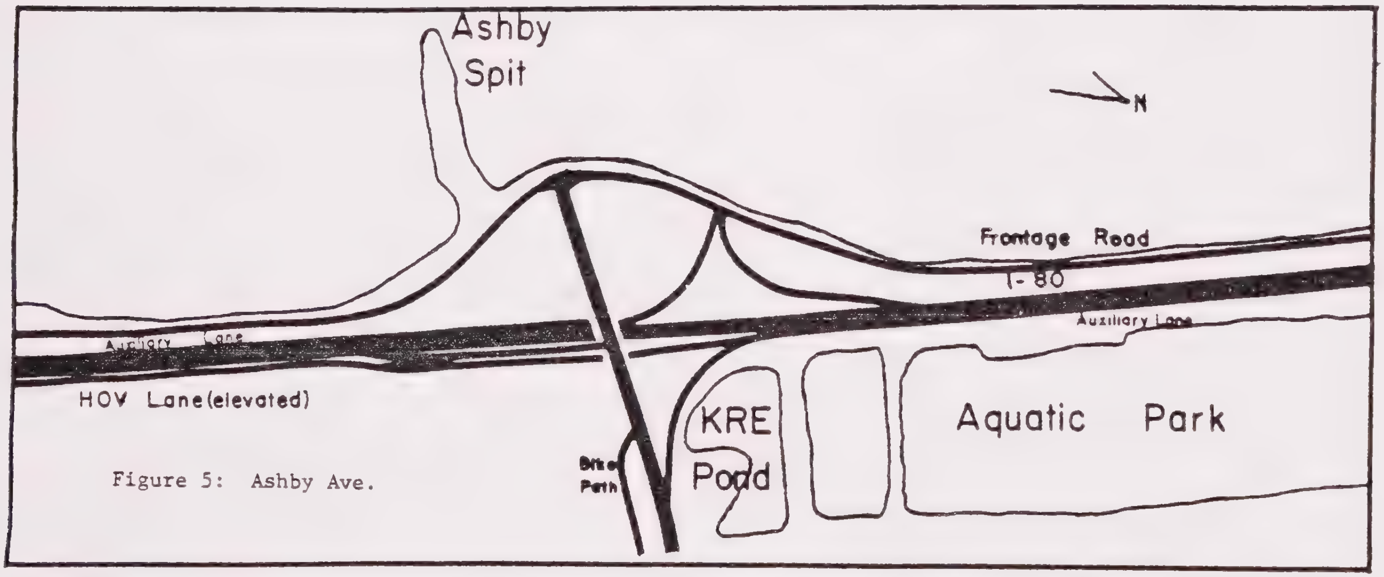

Figure 5: Ashby Ave.

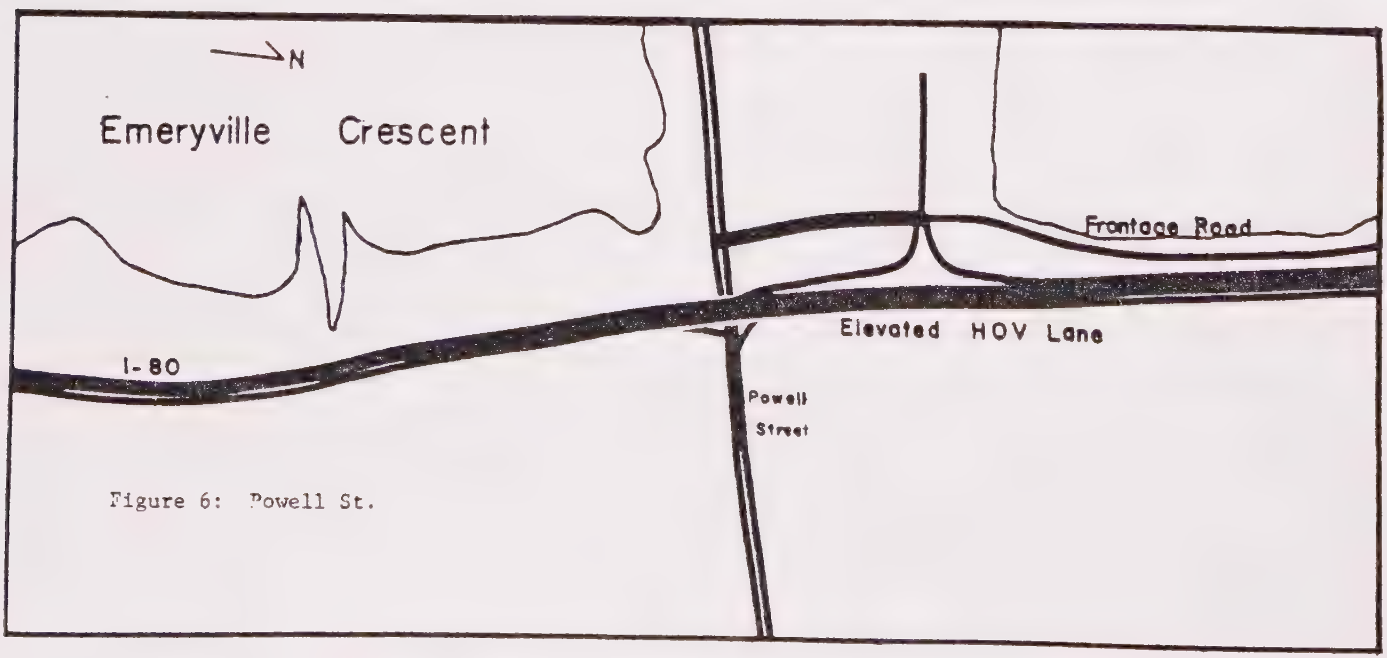

Figure 6: Powell St.

Source: Base Map: CHMNB; Changes: Preliminary Geometrics from Caltrans

Caltrans also plans to reduce the congestion which now takes place at the intersection of University Avenue, Frontage Road, and the interchange. Its proposal is to move Frontage Road west at that point, increasing the distance between that intersection and the highway entrance.

Since Berkeley is the major city along this stretch of I-80 and the shoreline area could become a showcase to visitors and for the community, providing adequate access across the highway at University Avenue is critical for any future development, commercial or recreational. With the continued joint effort by Caltrans and the City of Berkeley, this may be realized.

Ashby Avenue

The Ashby Avenue interchange is located between University Avenue (to the north) and Powell Street (to the south). Originally, this interchange was to have been a major connector between I-80 and I-13 (Ashby Avenue) (Forsen, pers. comm., 1982). However, this plan fell through, making the elaborate cloverleaf ramps unnecessary. Access is not an important issue now, but may be later if one of the proposals, that of a Berkeley Beach or a regiona trail, is implemented.

Presently, provision for access to this location is not one of the larger issues along the shoreline, since only Ashby Spit is there. Fishermen do use this area for fishing, but rely on cars to reach this site. A beach, piers, or buildings may be constructed in the future, which would make having access by bikes and pedestrians an issue. Furthermore, the possibility of making the shoreline accessible from Aquatic Park makes it even more worthy of consideration now. The only access now is by auto and other motor vehicle. A pedestrian walkway doesn't go anywhere; it just ends. Therefore, Caltrans has designed a new ramp that will eliminate the cloverleaf and increase the uses of the ramp.

The proposed plan is to build a single overpass in place of the two curving ones (FIGURE 5). This would simplify the intersection with Frontage Road and allow the inclusion of a pedestrian walkway and bike lane, permitting access to a point where none is now offered.

Bicycles can only reach Ashby Spit, located at this spot on the shoreline, if they travel in a very round-about fashion from either Powell Street or Gilman Street along Frontage Road which, presently, has no bike lane.

Caltrans has taken into consideration the need for improved bicycle and pedestrian access. A bike lane is included in the proposal, but the bicyclist still

would be forced to ride on the roadway with the automobiles with only a painted line separating him or her from the cars. When funds are available, a separate pedestrian/bike overpass should be considered as a safer alternative.

Powell Street

Powell Street is approximately a mile south of Ashby Avenue. This access point is basically a street under a freeway overpass. It provides access to the shoreline (primarily the Emeryville Crescent) and the Emeryville Marina. Because of this, large flows of traffic often occur which, as in the case of Gilman Street, decrease pedestrian and bicyclist safety. Powell Street also serves as a major on-ramp area to I-80 during rush hours, with traffic often backing up quite a distance along Frontage Road.

However, when traffic is not a problem, Powell Street is a very good way for bicyclists and pedestrians to reach the shoreline. This is mainly due to the stoplights, which control the traffic, and the walkways provided. However, the ability to get to the intersection from the east needs to be improved, since bicyclists now have to share the roadway on the overpass above the Southern Pacific railroad tracks with cars.

A key ecologically-sensitive shoreline area, the Emeryville Crescent, is reached primarily through this access point. Questions have arisen over the amount of access which should be permitted to this fragile zone. In many respects, the ability of Powell Street to provide the best access along the shoreline in the greatest diversity of forms can, in this case, be a curse rather than a blessing, since the prevalent feeling is to reduce the amount of uncontrolled access to the Crescent, rather than encourage it. The present ease of accessibility at this location certainly doesn't discourage people from visiting the Crescent. Unfortunately, there is presently no means of excluding access to the Crescent, and a great deal of damage is occurring because of this (see papers by Doyle, Olson, and Cohen).

There are three possible solutions to this problem. One is to do nothing and leave it the way it is. The second one is to exclude access to the area totally, most likely with fences. And thirdly, access could be controlled in some fashion. This could be accomplished by having a person staff an information office. Or it could be by constructing pathways with physical barriers separating visitors from

the marsh. This last method would also serve to reduce the adverse impact from dogs, although excluding them from the area completely would be the best solution.

It is my personal belief that the third solution may be the best. It is virtually impossible to exclude access totally to an area. Sometimes this even backfires and encourages more people to use it. It is also impossible to leave the situation the way it is if we want to see the Crescent preserved as important wildlife habitat.

Caltrans' proposed plan is to shift the westbound highway on- and off-ramp interchange north so that cars will be entering the highway before actually reaching Powell Street (FIGURE 6). This requires shifting Frontage Road westward at the point where the new off-ramp occurs. The eastbound on- and off-ramps will be unchanged. The function of this shift is to allow more time for cars to change lanes to Highways 17 or 580.

Discussion

In regard to the East Bay shoreline access problems, several questions require very careful consideration: who will provide access? how much access should be allowed? and what type of access should be encouraged and/or discouraged? A solution to these problems involves a process which demands that the different "actors" work on the answers together. Fortunately, the timing of various shoreline projects is going to encourage this, and in some instances, actually force it to occur. All to often local agencies have no idea what the state departments, such as Caltrans, have planned. This could lead to work on an area by a city which would soon be rendered useless by a Caltrans proposal which the city knew nothing about. The time, money, and manpower from the wasted project could be better put to use elsewhere. It is hoped that this can be avoided for the majority of the proposed shoreline projects.

The Coastal Conservancy has acted as a means of providing some coordination, at least in terms of identifying what needs to be addressed and in keeping other state agencies informed. This has helped in the development of an overall draft proposal for the East Bay shoreline. Fortunately, the majority of the access issues mentioned in the proposal are also being addressed by Caltrans. Access within and to each location, however, is still primarily up to the cities. Unfortunately, how

they approach the access issue may not be based on what is needed, but on what is the most economical. If the shoreline hopes to have a bright future independent of what physical development occurs, though, access by pedestrians and bicycles will have to be improved. Caltrans has already taken the initial steps in insuring that this will be the case. It is hoped that the cities will follow suit.

The one critical factor that each of the planning and permit-granting agencies have to consider concerns the encouragement or discouragement of cars at the shoreline. If the use of cars along the shoreline is to be encouraged, then adequate parking facilities will need to be constructed, adding further costs to any project.

Discouraging cars is not always desirable, since it means that alternative forms of access will need to be readily available (or planned for). These alternatives can be just as difficult to provide as parking. However, since the local and state agencies are communicating with each other, the decrease of problems in coordination makes this option of discouraging cars more inviting. This is a good sign and shows that positive results are emerging from this project.

Another important aspect of access was brought up in an earlier seminar report by Kin Yee (Yee, 1978, p. 18). Public awareness and information on the available recreational areas along the shoreline and associated ways to get there are very important to the overall "health" of the shoreline. This is especially true at University Avenue with the proposed bike lane modifications. Not only do people need to know that they can reach the shoreline by bike, they also need to know how.

Summary

It would appear that access to the East Bay shoreline will be improved, primarily due to Caltrans. It has addressed the key access issues under its jurisdiction and appears very sensitive to the many problems raised concerning the present and future use of the shoreline. However, the dilemma of whether or not to provide access is still a subject of debate. Careful handling of this problem in ecologically-sensitive areas is mandatory.

I feel the proposed plans by Caltrans for the shoreline are aimed at alleviating the congestion on the highway and the adjacent shoreline areas. A good example of this is the I-80/I-180 junction, where the modifications at the entrances and exits to the highway will greatly improve the safety of the nearby streets, as well as the highway. These changes, in turn, should enhance the overall appeal of the shoreline and encourage people to visit the shoreline.

An interesting question arises of what to do with the land freed by Caltrans through its changes. In the case of University Avenue, a small parking area in the centrally-located Berkeley Marina area may be the best option. A small parcel of land, such as land freed by the elimination of the westbound off-ramp could be used. This would then discourage cars from parking in areas which are not suited for them. But cooperation between the various cities would definitely be necessary to realize this use.

The trail along this stretch of shoreline could easily be made safe by the closure of the westernmost lane on Frontage Road between University and Ashby Avenues, but this solution does not apply to the remainder of the shoreline. Although it may be possible to convince BCDC to allow the addition of enough landfill to make a safe bike path along the other areas of the shoreline adjacent to Frontage Road, another alternative is available. This would be to run a shuttle bus between the three major shoreline areas: Gilman Street, University Avenue and Powell Street. Further to discourage cars at the shoreline while promoting pedestrian use, the shuttle also could have stops on the east side of the highway at those points. At University Avenue this might serve as a connection between the shoreline and Aquatic Park. It also could be used as part of a handicapped access system with a Dial-a-Ride program which would bring the handicapped to the shuttle stops, making more efficient use of each system.

At Powell Street a similar area of land is freed by the modification of the on- and off-ramps. Although it could easily be converted to a parking lot, that probably would not be in the best interest of the Crescent. More likely, the land could be the staging area for a short self-guided tour of the Crescent, similar to what is seen at the Hayward shoreline.

It is clear that no matter what changes do take place along the shoreline, access to it will play a major role in its ultimate development.

REFERENCES CITED

Forsen, Hilmer A., P.E., Head Engineer on Highway 80 project, Caltrans; pers. comm., February 19 and May 19, 1982.

Larson, Krieg, Associate Environmental Planner, Caltrans; pers. comm., February 16 and May 19, 1982.

Yee, Kin, 1978, Access to Parks, pp. 13-20, in East Bay Parklands: Planning and Management, Senior Seminar, Environmental Studies Group.